Control ENGINEERING

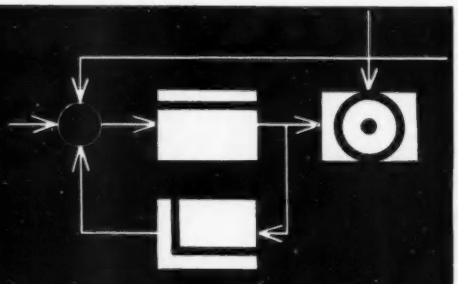
INSTRUMENTATION AND CONTROL SYSTEMS

A McGraw-Hill Publication

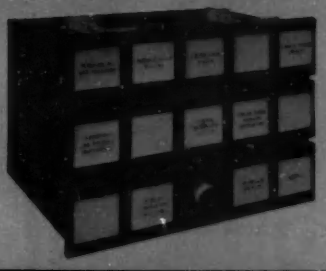
75 Cents

JULY 1959

Short-Cut to Analog Computer Circuits

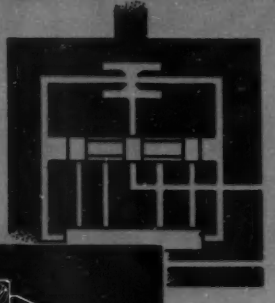


Alarm Annunciators: Industry's Watchdogs

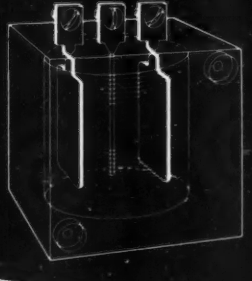


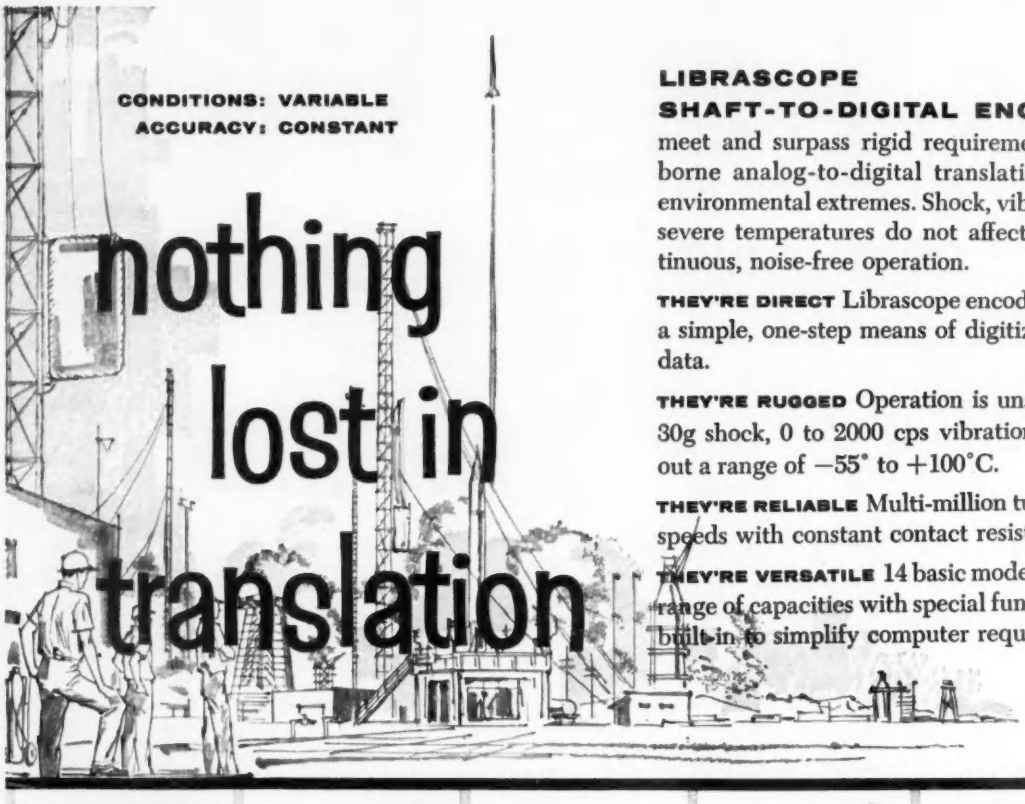
Spotting Trouble in New EDP Installations

Integrated Feedback Improves Servovalves



A Remarkable New Static Switch





LIBRASCOPE SHAFT-TO-DIGITAL ENCODERS meet and surpass rigid requirements of airborne analog-to-digital translation despite environmental extremes. Shock, vibration, and severe temperatures do not affect their continuous, noise-free operation.

THEY'RE DIRECT Librascope encoders provide a simple, one-step means of digitizing analog data.

THEY'RE RUGGED Operation is unaffected by 30g shock, 0 to 2000 cps vibration, throughout a range of −55° to +100°C.

THEY'RE RELIABLE Multi-million turns at high speeds with constant contact resistance.

THEY'RE VERSATILE 14 basic models in a wide range of capacities with special function codes built-in to simplify computer requirements.

MODEL 740 | MODEL 713 | MODEL 758 | MODEL 724 | MODEL 708

OUTPUT CODE	MODEL NO. ⓖ	TOTAL CAPACITY	RESOLUTION PER TURN	DIMENSIONS DIA. x LENGTH
PARALLEL BINARY (LINEAR)	740	10 bits (1024)	1024	4 9/16" x 2 1/4"
	743	13 bits (8192)	128	2" x 3 1/32"
SERIAL BINARY (LINEAR)	707	7 bits (128)	128	2" x 2 9/64"
	713	13 bits (8192)	128	2" x 3 1/32"
	717	17 bits (131,072)	128	2" x 4 13/64"
	719	19 bits (524,288)	128	2" x 4 13/64"
SERIAL BINARY (SIN-COS)	757†	7 bits per quadrant* (4 quadrants)	512	2 1/4" x 4 1/16"
	758†	8 bits per quadrant* (4 quadrants)	1024	4 1/16" x 3 1/16"
BINARY CODED DECIMAL (8-4-2-1)	723	2,000	200	3 1/16" x 4 37/64"
	724	20,000	200	3 1/16" x 4 37/64"
	733	3,600	200	3 1/16" x 4 37/64"
	734	36,000	200	3 1/16" x 6 3/4"
	735	360,000	200	3 1/16" x 6 3/4"
GRAY	708	8 bits (256)	256	3 1/16" x 1 13/16"

ⓖAll models available with internally mounted isolation diodes for sequential multiplexing applications.

†Available in hermetically sealed servo-driven package as Models 757-S and 758-S.

*Including limit 1 and polarity information. Sine and cosine functions generated simultaneously and independently. One turn of shaft generates 4 quadrants of information.

For full details on Librascope shaft-to-digital encoders write for catalog E 11-1.

L19-1

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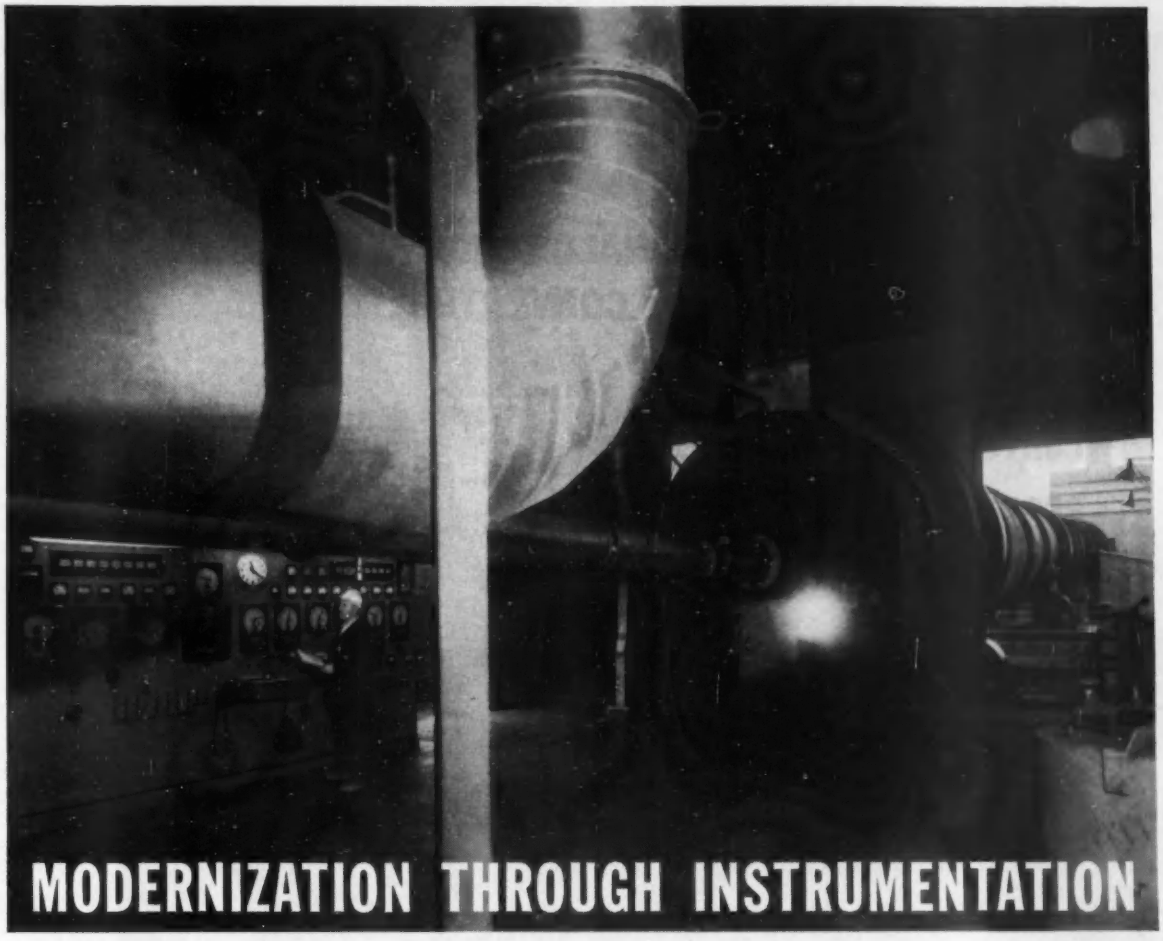
LIBRASCOPE, INC. 40 East Verdugo Avenue • Burbank, Calif.

CIRCLE 1 ON READER-SERVICE CARD



MODERNIZATION THROUGH INSTRUMENTATION

Key to growth and profit for Marquette Cement

With capacity at new peaks, Marquette Cement is turning to modernization programs to help maintain the profit margin in these days of rising costs and increasing competition.

And at Marquette, engineer, controller and production man alike recognize the advantages of modern instrumentation and automation to help achieve their goals.

For instance, at their Nashville, Tennessee plant, low-cost high-quality clinker is being produced with the help of new instrumentation by Leeds & Northrup, the *most experienced* supplier of instruments and controls to the industry.

Using economical Speedomax® Type H recorder-controllers as basic measuring and control instruments, this new system, constructed by Allis-Chalmers, provides for automatic control of the 5 most important kiln conditions and continuous recording of 4 additional critical variables.

Like Marquette, other major producers are taking long hard looks at the future . . . examining processes for savings through instrumentation.

And they're finding that instrumentation *can* help widen the profit margin . . . not only in the kiln department but throughout the plant . . . in raw material handling, blending and grinding.

Your Leeds & Northrup engineer can show you now how proven L&N systems have helped others toward growth and profit. Call him at your nearby L&N office, or write to 4918 Stenton Avenue, Phila. 44, Pa., for diagrams and data sheets.

LEEDS Instruments NORTHRUP Automatic Controls • Furnaces

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an Epsco transistorized

TRANSICON DATRAC® ANALOG-DIGITAL CONVERTER

can solve your data conversion problem . . . economically!

designed FOR YOUR SYSTEM by system specialists who have pioneered the field of high-speed, reversible analog-to-digital conversion . . .

- **PRODUCTION ENGINEERED** to be the lowest-cost transistorized converters available anywhere.
- **MODULARIZED**—plug-in building-blocks permit assembly of over 50 standard models.
- **EASY TO USE**—no adjustments
- **HIGH SPEED**—up to 25,000 conversions/sec analog-to-digital; up to 100,000 conversions/sec digital-to-analog
- **HIGH POWER DIGITAL OUTPUTS**
- **DIGITIZES BOTH CURRENTS AND VOLTAGES**
- **PARALLEL AND SERIAL CODED OUTPUTS**
- **BUILT-IN EXPANDABILITY**—8-bit converters to 10, 12 or 14 bits; changing codes from binary to binary-coded decimal; making an analog-to-digital converter from a digital-to-analog unit

. . . and an Epsco Exclusive: PROVEN RELIABILITY One million hours of operation in hundreds of installations around the world have proven DATRAC reliability. Now an all solid state TRANSICON DATRAC assures even greater performance.

New 6-page, 2-color brochure available with complete description of TRANSICON DATRACS. Write, wire or phone your local Epsco representative or contact, in the East: Epsco, Inc., Equipment Division, 588 Commonwealth Avenue, Boston 15, Massachusetts; in the West: Epsco-West, 125 E. Orangethorpe Ave., Anaheim, California.

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Data Logging Systems
Telemetry Data Reduction
Digital Transmission over Telephone Lines
Analog Digital Computer Linkages
Wind Tunnel Instrumentation

TRANSICON DIGITAL-TO-ANALOG CONVERTERS FOR . . .

Driving Analog Plotters from Digital Sources
Analog Displays on Meters and Oscillographs from Digital Codes
Analog Computer Inputs
Radar Display Drivers
Fire Control Simulators

TRANSICON ALARM LIMIT MONITORS FOR . . .

Automatic Checkout Systems
High-speed Fault Analyzers
Power Plant Monitors
Industrial Process Controllers

Epsco

First in data control

Control ENGINEERING

JULY 1959
VOL. 6 NO. 7

Published for engineers and technical management men who are responsible for the design, application, and test of instrumentation and automatic control systems

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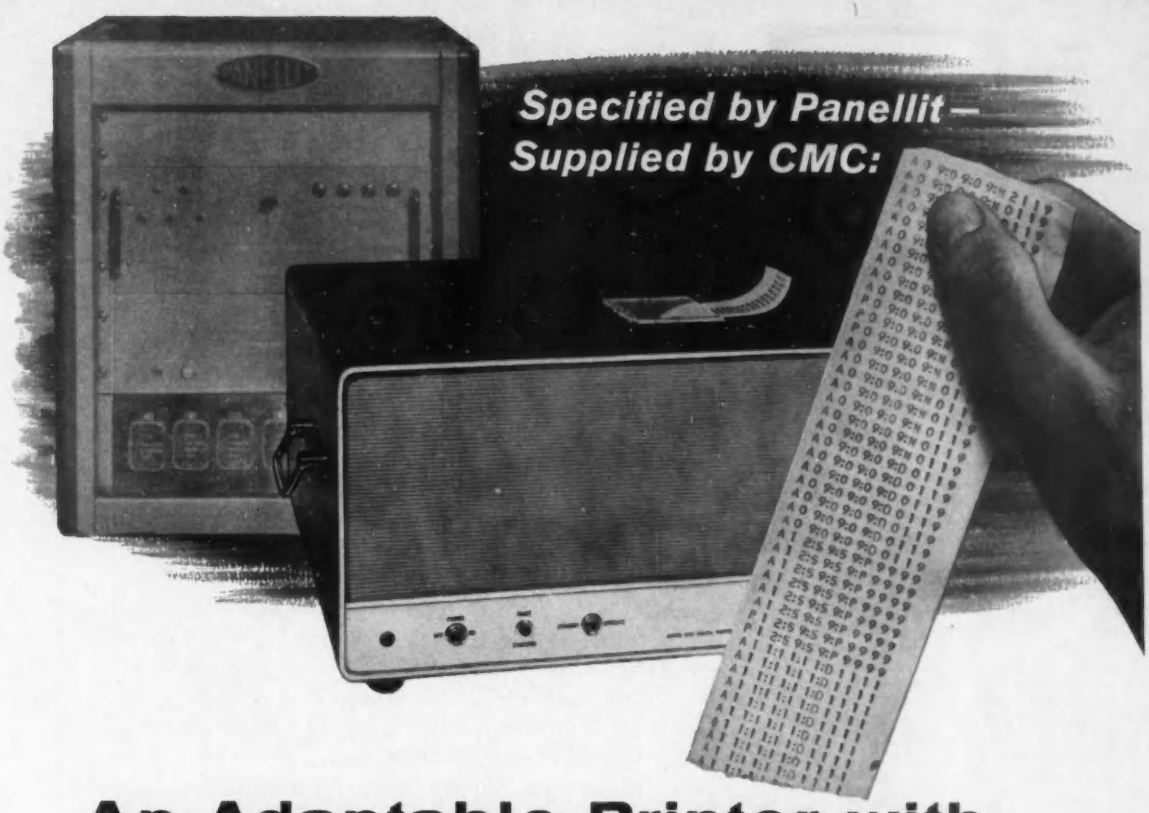

An Adaptable Printer with Day In-Day Out Reliability

Understandably, Panellit's requirements for a digital printer were strict. The Skokie, Illinois firm's recording annunciator, which monitors trouble in equipment operations, has to have around-the-clock reliability. It has to indicate what went wrong, exactly when it went wrong, and for how long. In many instances, the printer must operate at remote stations, unattended. Panellit chose CMC's new digital printer to provide this high degree of dependability.

READILY ADAPTED

The tape above shows the adaptability of CMC's printer to special applications. The Panellit system scans a number of points and then records, in a single twelve digit printout, the off-normal point, the off-normal code, the hour, minute and hundredth of a minute. The date is printed every twelve hours and on demand.

The system detects the first off-normal to a one cycle accuracy and records sequentially at the rate of four alarms per second. Alarms occurring faster are stored in the memory unit and printed according to a built-in sequence. The entire record is neat, compact and permanent.

PRINTER FEATURES

No stepping switches ★ 4 lines per second printout ★ parallel entry ★ 8 options... 10 line output to drive punches and electric typewriters, analog output to drive strip chart recorder, inline readout, accumulator, code converter, transistorized drive, add-subtract solenoid, print-line identification ★ rugged unitized construction ★ compatible with any line of counting equipment.

KEY SPECIFICATIONS • Model 400C Digital Printer

Print-out capacity 6 digits standard, up to 12 on special order. Accuracy determined by basic counting instrument... display time 0.2 seconds minimum, maximum controlled by counter or system. Weight 64 lbs.

CMC engineering representatives are located in principal cities. For complete information on this all-new instrument, phone your nearby representative or write directly to Dept. 087.

Computer-Measurements Company *A Division of Pacific Industries, Inc.*

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15

CIRCLE 6 ON READER-SERVICE CARD

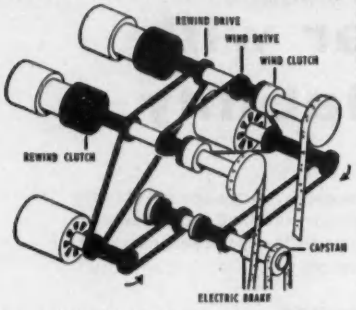
electric motion control FACTS for IDEA MEN

Electromagnetic power drive controlled from servo outputs

PROBLEM: Vary the feed of a magnetic tape drive from 10 to 180 in. per second, depending on velocity *or* amount of information to be read from the tape.

SOLUTION: Four Warner electric clutches were used to control the reel and one electric brake to control the capstan, establishing dual operation from feedback voltages. A tachometer on the capstan drive generates a voltage proportional to the tape speed. Information on the tape itself generates another voltage, which, if greater than the tachometer voltage, is electronically compared to a reference voltage reflecting the requirements and limitations of the connecting equipment.

The tape reader must be capable of handling one parallel group of pulses (a single digit) at a time. Therefore, lines are packed 20 to an inch, which means a complete stop-



start cycle within 1/20 of an inch. Actually, torque build-up periods of the brakes and clutches overlap each other, permitting instantaneous response to the error signal. Thus, tape may be advanced a line, a block, or a single digit at a time, leaving enough space for acceleration to required speed and proper reading of the next information bit.

Assembly advantages

Leads to the clutch and brake coils are integral with the field assembly—there are no slip rings or brushes. Build-up of current in the field, engagement of the armature and rotor (or replaceable face), and full operation are accomplished in milliseconds.

Send for more IDEAS

Write for factual application sheets showing how machines are made more productive, easier to control, simpler to maintain.

WARNER **ELECTRIC BRAKES AND CLUTCHES**

Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

CIRCLE 7 ON READER-SERVICE CARD

SHOPTALK

Why not?

In February a Canadian subscriber commended our perforating of feature pages and urged us to place advertisements between articles so that the removal of one article would not destroy a page of each adjoining article. His suggestion is but one in a long stream of similar requests since the first issue of CONTROL ENGINEERING was mailed in August 1954.

Should we be conservative and refuse? We haggled and we fussed, and finally decided to turn the question over to you for arbitration. So that you can decide, this and the August issue will carry inter-article advertisements. It's an experiment. Tell us how you like it.

Further up the ivory tower

Dr. Gordon S. Brown, for the past seven years Head of the Department of Electrical Engineering at the Massachusetts Institute of Technology, has been appointed Dean of the School of Engineering at MIT, effective July 1, 1959. As CONTROL ENGINEERING's senior consulting editor. Gordon has imbued CtE's editors with many of the new philosophies in engineering and education that he developed as head of EE. Now the whole MIT School of Engineering can profit from his foresightedness. Congratulations to Dr. Brown.

Correspondent at work

Thought you might be interested in what our Japanese correspondent, Kazuto Togino, looks like. Photo shows Kazuto (left) on a CtE field trip, with M. Y. Hata (engineer at Tokyo Denki-Kagaku Co.) explaining features of a dual-frequency core memory device used as high-speed storage in a parametron digital computer.

Control engineer exhibits broad scope

You might say that H. W. Cory grew up with the control field, from designing temperature control systems for Barber-Colman 18 years ago to Assistant Manager of the Allis-Chalmers' Control Department today. During this period Hal has done everything from developing new propulsion control methods for submarines, to applying many of the new mathematical techniques for analyzing feedback control systems, to creating new electronic control systems for high-speed paper machines. All of which eminently qualifies him for his latest extracurricular position; chairman of the Scope Committee of the new NEMA Industrial Automatic System Section. For the details see "Guest Editorial", page 79 and "What's New", page 30.

THIS

TELEMETER

MAGNETICS

MEMORY CORE

SUPPORTS

THE WEIGHT

OF ONE

YOUNG

ELEPHANT

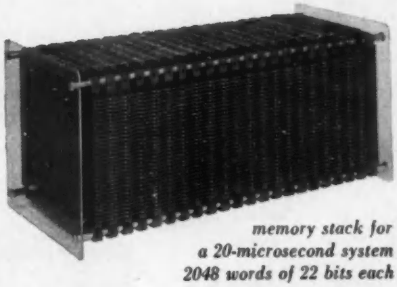
has a faster, more reliable memory, too!

quality control series no. 1

STRENGTH TEST

SILLY TEST

but we hope it attracts your attention to the thorough three-stage inspection and testing given every TELEMETER MAGNETICS memory product — from core to array to buffers and memory systems.



memory stack for a 20-microsecond system 2048 words of 22 bits each

economical • reliable • fast • Telemeter Magnetics Modular Memory Systems are designed and manufactured for absolute dependability

Because TELEMETER MAGNETICS manufactures the memory system complete from core production through array wiring to finished units... and because TELEMETER MAGNETICS tests each phase of production thoroughly... you can be that much surer when you specify memory systems designed and engineered by TMI.

Modular design permits production of custom memory systems to satisfy practically any desired configuration. Units of from 100 to 1,000,000 bits are common... memories can be supplied incorporating several million bits. In addition, TMI offers you a selection of memory units with cycle times of 24 microseconds, 6 to 8 microseconds, and 3 microseconds.

Electronic circuits in TELEMETER MAGNETICS memory systems employ solid state elements throughout... transistors, diodes and ferrite cores. Amplifiers, registers, drivers, and logic are on plug-in cards for compactness and maintenance ease.

write for specifications and complete information.
Manufacturers of ferrite cores • core arrays • buffers • memories

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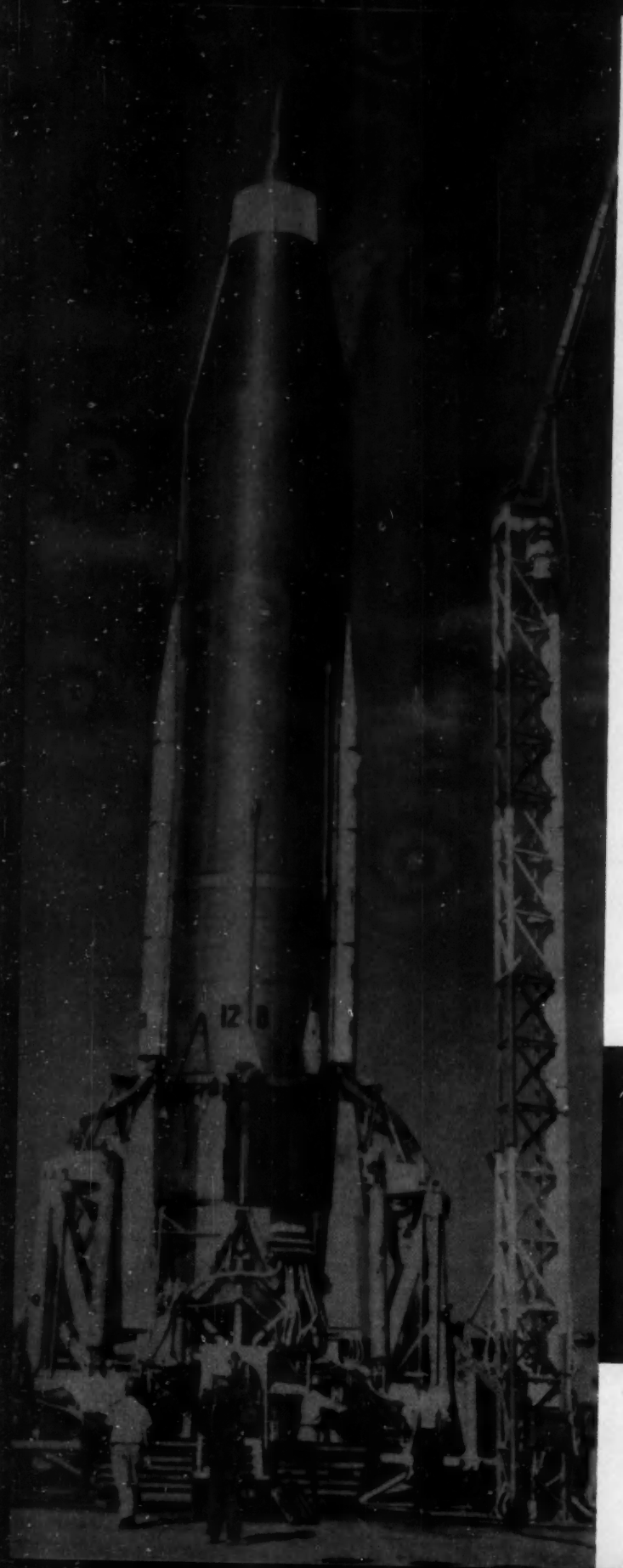
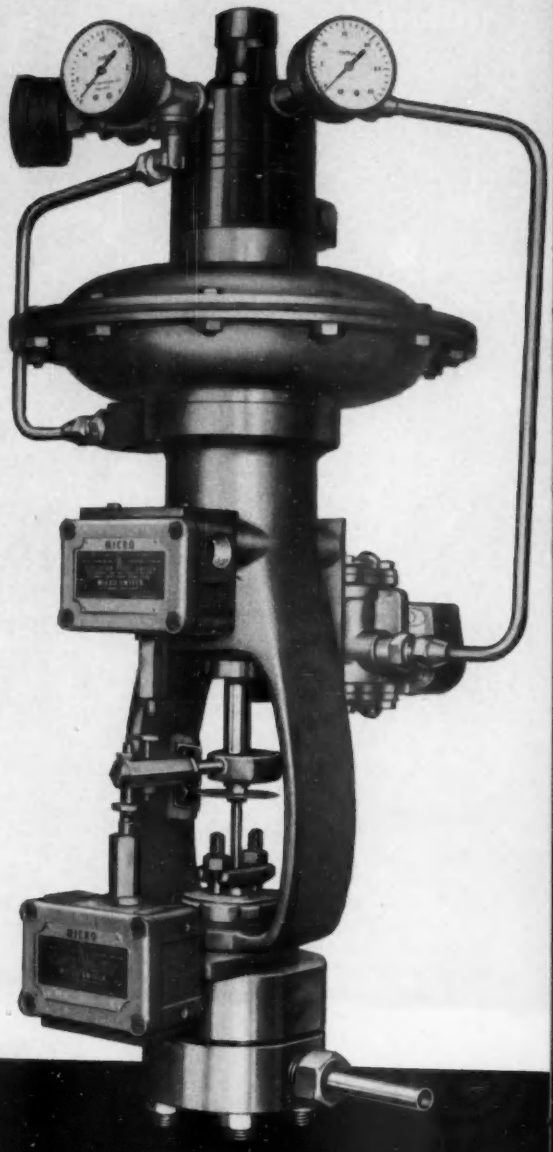
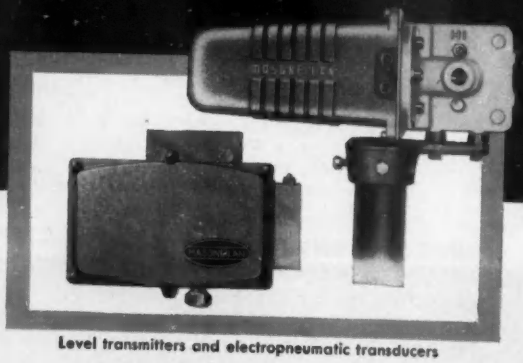




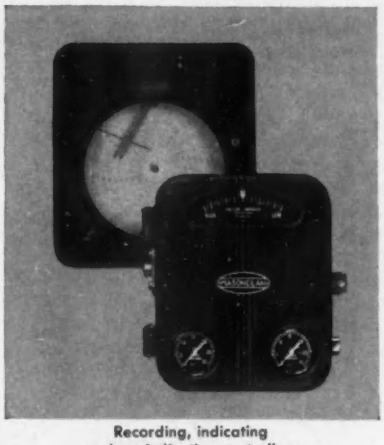
Split body control valve
with high pressure connections for welding



Level transmitters and electropneumatic transducers

Processing or Missile Ground Support Systems...

DEPENDABLE CONTROL
is Assured with Masoneilan Equipment



Recording, indicating and nonindicating controllers

The built-in accuracy and stamina for which Masoneilan controls have long been noted in the process industries, make them equally suitable for the critical operational requirements of missile ground support systems.

Mason-Neilan offers a wide selection of equipment, including...

- Instruments for control or transmission.
- Control valves especially adapted to low temperature service on liquefied gases, featuring tight shutoff and fast, powerful actuators.
- Control consoles with completely piped and wired systems.

For product information and engineering consultation, contact the nearest Mason-Neilan office or representative — or write direct.

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HNS-8

Globe valve with extension bonnet for low temperature service

10000 Series control valve for process applications

Console panels with complete instrumentation

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LINEAR MOTION POTENTIOMETERS

FROM

Edcliff INSTRUMENTS

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PERFORMANCE PROVED

Edcliff Instruments' Linear Motion Potentiometers, built per MIL-E-5272A specifications, offer proven reliability. Available with mounting and connection configurations to meet your application requirements, Edcliff Model 3-43 Potentiometers are designed for long operational life under rugged environmental conditions.

The complete line of Edcliff Instruments' Linear Motion Potentiometers is available end, side or bottom actuated with strokes up to 15 inches. They have high resolution, linearities to 0.05% and center or function taps. Engineered for reliable operation in high ambient temperatures, units are produced with one to four elements, depending upon the requirements of the particular application.

The full product line from Edcliff Instruments also includes Pressure Potentiometers, Angle of Attack Meters, Angular Accelerometers, Linear Accelerometers and Differential Transformer type Accelerometers.

Information on price and delivery is available from your local Edcliff Instruments representative or the factory.

Write for Bulletin S11-WJ.

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CIRCLE 10 ON READER-SERVICE CARD

FEEDBACK

READERS' CONTROL WORKSHOP

A level standard for rocket fuel

TO THE EDITOR—

We are striving toward obtaining a continuous indicating primary level standard for cryogenic fluids. It would be used for calibration and accuracy checks of all of our airborne liquid-level systems. An accuracy of plus-or-minus $\frac{1}{32}$ in. in a 30-in. diameter by 260-in.-long container is desired. The container is located outdoors, subject to rain, snow, and ambient temperatures of minus 5 to plus 95 deg F. The fluid inside the container boils; its surface activity varies from 5 in. to 9 in. We have found that the surface inside a stillwell was quiescent.

Can you please supply us with information on liquid-level sensors for this application?

Anthony Ackerman
Denver, Colo

A detailed answer on accuracy

TO THE EDITOR—

There are several conventional means of measuring the levels of these liquefied gases and each would have a corresponding nominal degree of accuracy if installed in the ambient condition mentioned. These are:

1. Force-balance level-type instrument with a nominal expected accuracy of plus or minus 1 in. of level.
2. Electronic capacitance probe level device with an accuracy of $\frac{1}{8}$ to $\frac{1}{4}$ in. of level.
3. Mechanical float-operated level gage operating in a stillwell, with an accuracy of $\frac{1}{4}$ in.
4. Static manometer device purged by helium or some inert gas to separate the fluid from the measuring media, with an accuracy of $\frac{1}{8}$ in.

A 2:1 or 3:1 increase in accuracy of any of the devices mentioned could be expected if level determination were desired at only fixed intervals. This would minimize the inherent hysteresis effects and permit finer adjustments and settings of the measuring devices. However, it would not permit a continuous measurement of level but only provide indication at prescribed points, such as empty, quarter-full, half-full, three-quarter full, and full.

Ralph L. Shapcott
Fischer & Porter Co.
Hatboro, Pa.

In addition, the container must be calibrated and its designer must avoid odd shapes, such as expansion sections or dished heads, that might effect variations in density. Ed.

Information, please—flame-cutting

TO THE EDITOR—

Our attention was recently drawn to an article in your publication on a new type of flame-cutter jointly developed by British Oxygen Gases and Ferranti, Lt.

We desire to keep abreast of the latest developments in new burning equipment for our plant. It would be appreciated, therefore, if you could furnish us with more complete details of the new flame-cutter, or alternatively, advise us of the proper source to contact to obtain this information.

J. Surgenor
Burrard Dry Dock Co, Ltd.
North Vancouver, B. C., Canada

Obtain further details on the BOG automatic flame-cutter from G. Sims-Davies of BOG, Spencer House, St. James Place, London.

Introduced since the article in Control Engineering is the new EMI-Hancock machine, of comparable size and performance to the BOG. Sales point of the EMI system is simplified programming. Arthur Pearson of the Industrial Applications Div., EMI Electronics, Ltd., Hayes, Middlesex, will give you all the details. Ed.

Information please—standards

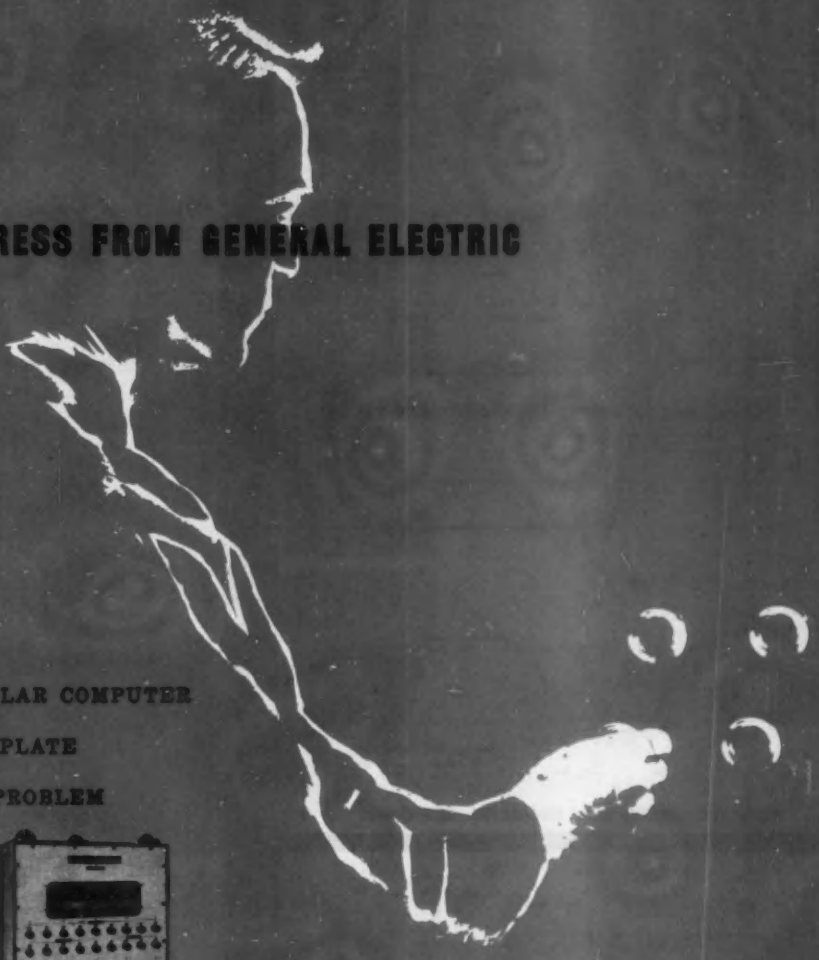
TO THE EDITOR—

An article entitled "Electronic Standards for Industrial Equipment" by the General Motors Electronics Committee appeared in the November '59 issue, pages 101 and 102. Technical personnel of this activity were very impressed with this article and would like to have the full publication of the standards as a reference item. This library would appreciate information as to publisher, publication date, price, etc., of the standards.

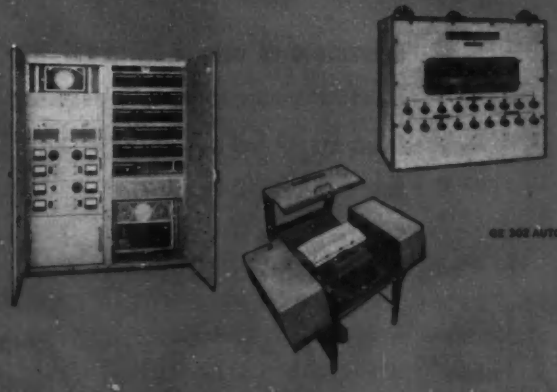
M. B. Zenich
White Sands Missile Range
New Mexico

Contact R. B. Colten, General Motors Technical Center. Ed.

COMPUTER PROGRESS FROM GENERAL ELECTRIC



CUSTOM DESIGNING MODULAR COMPUTER COMPONENTS TO SOLVE A TINPLATE INSPECTION AND BILLING PROBLEM



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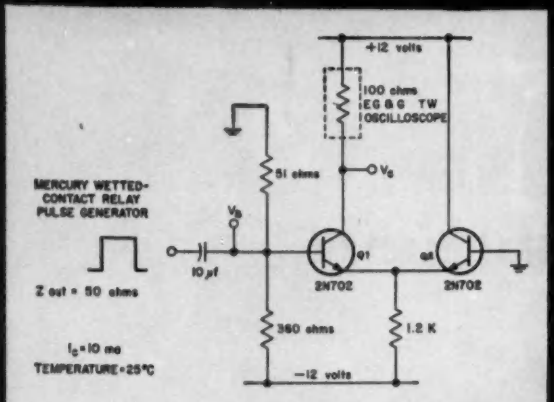
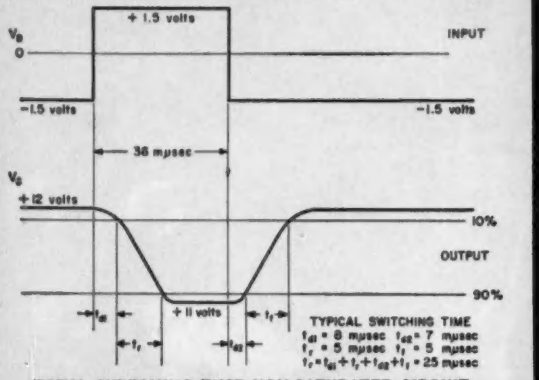
FOR FIGURES IN A HURRY – FIGURE ON A GE COMPUTER

CPB-14 (5-60)

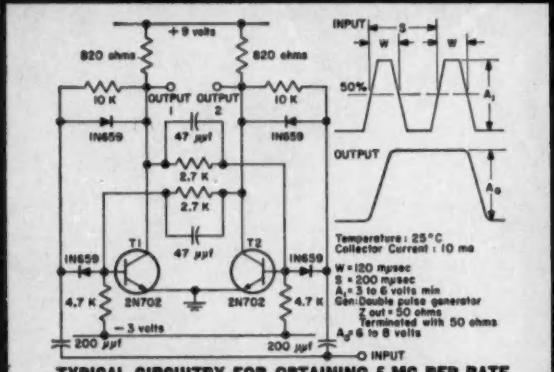
CIRCLE 11 ON READER-SERVICE CARD



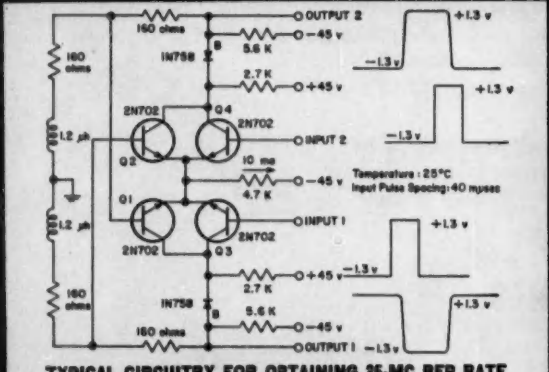
TYPICAL NON-SATURATED LOGIC SWITCHING CIRCUIT



TOTAL SWITCHING TIME NON-SATURATED CIRCUIT



TYPICAL CIRCUITRY FOR OBTAINING 5-MC REP RATE IN SATURATED FLIP-FLOP



TYPICAL CIRCUITRY FOR OBTAINING 25-MC REP RATE IN NON-SATURATED FLIP-FLOP

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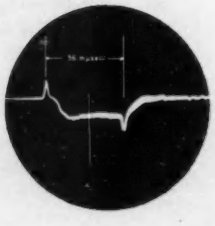

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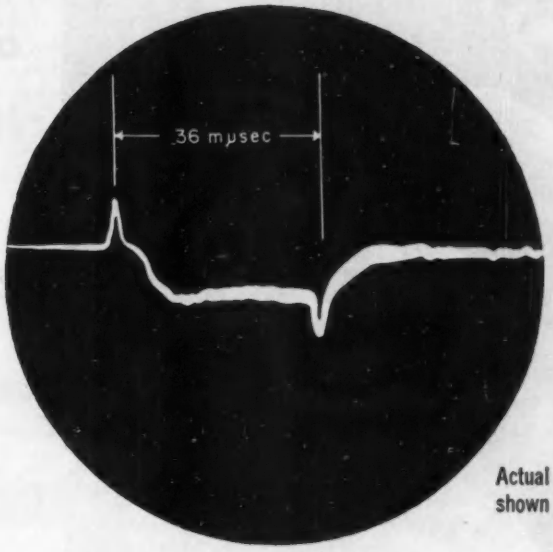

Actual photo of collector wave form as shown on traveling-wave oscilloscope

absolute maximum ratings (25°C)

Collector Voltage Referred to Base	20 v
Collector Voltage Referred to Emitter	15 v
Emitter Voltage Referred to Base	5 v
Collector Current	50 ma
Dissipation (100°C Free Air, Derate 0.5°C/mw)	150 mw

design characteristics at 25°C (except as indicated)

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10$ v, $I_E = 0$			0.5	μa
I_{CBO}	@ 150°C	$V_{CB} = 10$ v, $I_E = 0$			50	μa
BV_{CBO}	Breakdown Voltage	$I_{CBO} = 10$ μa, $I_E = 0$	20			v
BV_{CEO}	Breakdown Voltage	$I_{CEO} = 10$ μa, $I_B = 0$	15			v
h_{FE}*	DC Beta	$V_{CE} = 5$ v, $I_C = 10$ ma	15		45	
BV_{EBO}	Breakdown Voltage	$I_E = 10$ μa, $I_C = 0$	5			v
V_{BE}*	Input Voltage	$V_{CE} = 5$ v, $I_C = 10$ ma	0.7		1.2	v
C_{ob}	Output Capacitance	$V_{CB} = 5$ v, $I_E = 0$ f = 1 mc		7	12	μμf
f_t	Frequency at which h_{fe} is unity	$V_{CE} = 5$ v, $I_E = 10$ ma	50	100		mc
V_{CE}* (Sat)	Saturation Voltage	$I_C = 10$ ma, $I_B = 2$ ma			0.6	v

* Tested using pulse measurement.

NOTE: These units meet JEDEC outline TO-18 dimensions. A drawing of this package is attached.

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Yasundo Takahashi

imported modern control to Japan

One of the key figures behind Japan's resurgent control industry is a mild-mannered college professor who just recently took up residency in the United States to pursue advanced control technology. In 1948, as a neophyte in the control field, Yasundo Takahashi imported the technique of frequency response to his native island. Over the next eight years, he taught it, and applied it to industrial control, with such effect that an energetic young industry was born.

Takahashi has combined academic training in heat transfer with an interest in automatic control. As a serious student at Tokyo Imperial University, he majored in mechanical engineering, earned his degree of Ko-gakushi (a Japanese rank that falls somewhere between the American BS and MS degrees) in 1935. His first industrial experience, with the Japanese National Railways designing railway rolling stock, lacked the intellectual challenge that young Takahashi wanted, so he switched to a more demanding academic life, teaching and researching heat power systems. First, he was a lecturer at the Yokohama Technical College, then an assistant professor at Nagoya Imperial University. In 1946, his work in heat transfer systems earned him a doctorate degree.

By this time, of course, World War II had ended. Takahashi was hard hit psychologically, like many Japanese, and at a loss as to what to do for the future. He accepted a chair of dynamics of machinery at his alma mater, Tokyo Imperial University (whose name was promptly changed in postwar enthusiasm to University of Tokyo), although he had little experience in this area.

At this time, Takahashi was strongly influenced by the far-sighted chairman of Japan's National Science Council, Professor Kankuro Kaneshige, who told Takahashi that "automatic control would someday be the most important area of mechanical engineering". Takahashi took this suggestion to heart, launched a course in automatic control.

Putting together his first lecture notes was a herculean task. Most of the Japanese technical libraries had been destroyed by bombings; and contact with the outside was almost impossible. Still, Takahashi pieced together his notes by writing to control engineers in the U.S. and England, then combining their replies with technical papers. For the first four years, he spent practically all his working hours outside the classrooms going over papers from the U.S. and England.

In this way, he grasped the frequency-response technique developed at MIT, and from 1948 this became the backbone of his courses and his research. He put it to work in the industrial application of conventional control.

(Takahashi points out that the evolution of modern control technology in Japan has not paralleled developments in the U.S. Mechanical engineers pioneered Japanese control, not electrical engineers. The reason: a postwar ban on such things as fire-control systems stultified the development of servos and servo theory. EE's concentrated on such tasks as rebuilding power-generating and distribution systems using conventional approaches.)

At the university, Takahashi also concentrated on the transfer function analysis of heat exchange processes; and this was the subject of the first paper he prepared for presentation outside Japan. It was published in 1952 in England.

The diminutive control engineer has been a frequent contributor to Japanese scientific publications. In addition, he has written three books that are an important part of any Japanese control engineer's library. The trio: *Automatic Control* published in 1949, and *Theory of Automatic Control* and *Automatic Control Manual*, both published in 1954.

Takahashi's propensity to correspondence with

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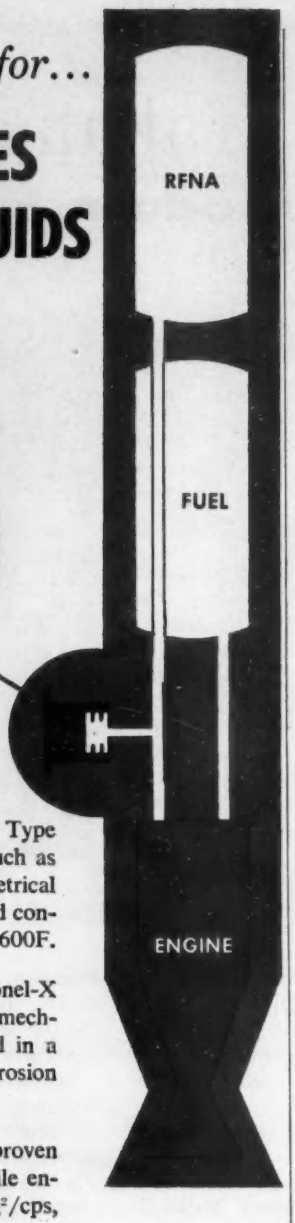

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CIRCLE 14 ON READER-SERVICE CARD

. . . TAKAHASHI: progress in Japan

foreign control engineers and his contributions to Japanese literature finally won him an international reputation. In 1954, he was awarded a grant to study control engineering at MIT as a Fulbright research scholar. The one-year stay in Boston was particularly welcome to Takahashi, because it gave him a chance to meet, and work with, some of the engineers who had introduced him to frequency response via the mail. Among them: Hank Paynter and Don Campbell.

At the end of his stay at MIT, Takahashi was invited to teach at the University of California as a visiting professor. In 1956, he went back to Tokyo, to the university and also as a consultant on the instrumentation for the Ajinomoto Co.'s new chemical plant and on nuclear power systems for the Mitsubishi Heavy Industry Co.

In February 1958, Takahashi returned to the United States, this time as a permanent member of the University of California faculty. In the Div. of Heat Power Systems, Dept. of Mechanical Engineering, at Berkeley, Takahashi is now pushing a couple of favorite projects that can be traced back to his early association with heat-power systems. He's studying the dynamic aspects of heat flow in heat exchangers, because he feels the knowledge may be a key to some kind of computing control that will permit optimizing the heat transfer process. And he's interested in sample data systems: how they might be applied to optimalizing thermal processes.

Teaching at an American University, Takahashi finds, is a lot different than teaching at a Japanese school. For one thing, U. S. students ask questions, lots of them. And this Japanese professor, who now speaks fluent English, likes the chance for discussion with his students. Takahashi also likes the idea of homework in the U. S. educational system (though much abused of late), feels it is much more effective than merely attending classes, as is done in Japan.

At Berkeley, Takahashi is building a first-rate process-control laboratory, a place where students can tinker with hardware; though he is the first to admit that he is a theoretician. "To me," says the man who brought frequency-response techniques to Japan, "controllers are just little black boxes." But his eyes sparkle when the conversation gets back to frequency-response techniques and how they can be applied to his favorite study—thermal processes.

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SC-32-1.5	0-32	0-1.5
2SC-32-1.5	0-32	0-1.5
DUAL OUTPUT	0-32	0-1.5
SC-32-2.5	0-32	0-2.5
SC-32-5	0-32	0-5
SC-32-10	0-32	0-10
SC-32-15	0-32	0-15
SC-60-2	0-60	0-2
SC-60-5	0-60	0-5
2SC-100-0.2	0-100	0-0.2
DUAL OUTPUT	0-100	0-0.2
SC-150-1	0-150	0-1
SC-300-1	0-300	0-1

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SC-18-2	0-18	0-2
SC-18-4	0-18	0-4
SC-36-0.5	0-36	0-0.5
SC-36-1	0-36	0-1
SC-36-2	0-36	0-2
SC-3672-0.5	36-72	0-0.5
SC-3672-1	36-72	0-1

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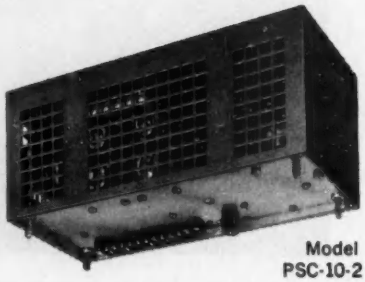

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PSC-10-2	7.5-12.5	2
PSC-15-2	12.5-17.5	2
PSC-20-2	17.5-22.5	2
PSC-28-1	22.5-32.5	1
PSC-38-1	32.5-42.5	1

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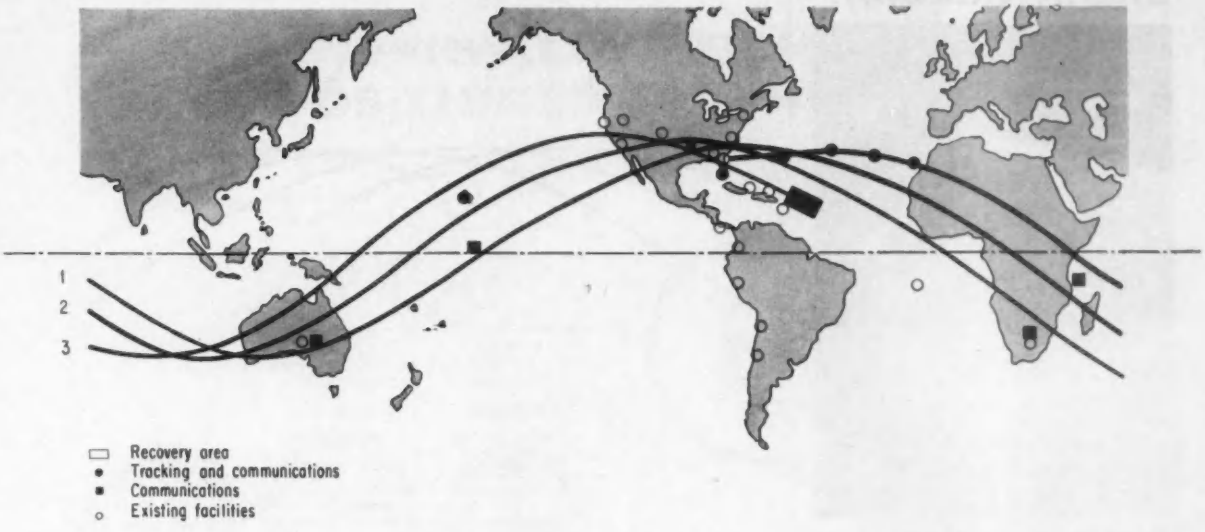


NASA Plans Global Range To Track Man In Space

In July NASA will award a multi-million dollar contract for the construction of an instrumented range to track the first man in space. The range has been designed for almost any eventuality as the first astronaut is launched into orbit, travels around the globe three times, and then returns safely to earth.

LANGLEY RESEARCH CENTER, VA.— This month the National Aeronautics and Space Administration will open bids for a world-wide tracking and telemetering range for Project Mercury–NASA's man-in-space program. The range will monitor the launch, orbit, and recovery of a manned satellite; and collect data on man's physiological and psychological capabilities while in orbit.

Overall responsibility for policy and planning of the manned satellite rests with NASA's Space Task Group, but scientists at Langley Research Center are overseeing for STG the new construction of the 17-station range. Scheduled completion date of the global tracking and telemetering range is May, 1960.

As a first step in obtaining bids, NASA invited prospective bidders to a preliminary session at Langley in April. Purpose of the meeting was to brief the potential contractors on NASA's plans for the range. Then in May, NASA issued a formal work statement and specification, which gave the bidding prime contractors time to team up with subcontractors having specific talents for this huge diversified, and dispersed engineering and construction project.

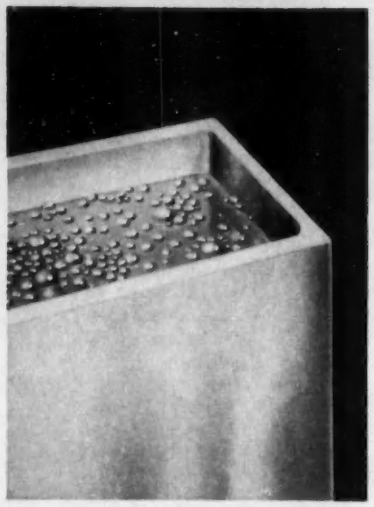
At Langley Research Center, assistant director Hartley A. Soulé recounted for CONTROL ENGINEERING what he and his associates disclosed to the would-be contractors at the April meeting. In summary, they talked about how NASA and other governmental agencies planned the key instrumentation phases of Project Mercury including the 11-station tracking network, the six-station telemetry and vehicle communication network, ground communication and data transmission, the computing center, and the control center.

• **Operational plans**–Sometime in 1960, the capsule without its human occupant will be launched from Cape Canaveral at a heading to pass south of Bermuda in a 33-deg orbit. Once aloft, the capsule will speed around the world three times in a 105-nautical mile circular orbit, and then land near San Salvador. Total flight time: about 270 min. This flight, short as it will be, will take years of comprehensive planning to cover every known contingency. Later, one of the specially-trained astronauts will make the same flight.

Using the range instrumentation, the men on the ground will know at every instant where the capsule is, where it is going, and how the space passenger is faring. The manned satellite dictates a high degree of tracking accuracy, an urgent need for real time computing capability and a new order of magnitude of reliability for communications.

While aloft, the capsule's instantaneous position will be determined by radar, and its future position predicted by a battery of computers at strategic locations. The astronaut will be under

ULTRASONIC BREAKTHROUGH!



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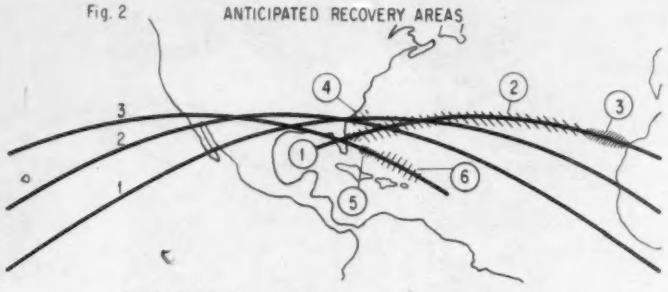
CIRCLE 17 ON READER-SERVICE CARD

Fig. 2 ANTICIPATED RECOVERY AREAS



	Name	Purpose
(1)	Cape Canaveral	Launch abort
(2)	Mid Atlantic	Sustainer abort
(3)	Canary Islands	Injection abort
(4)	Charleston	Flight emergency
(5)	San Salvador	Final recovery
(6)	Puerto Rico	Secondary recovery

GLOBAL RANGE . . .

STORY STARTS ON PAGE 19

surveillance by and in voice communication with aeromedical officers who will receive telemetered data about such physiological factors as pulse rate, heartbeat, and temperature, permitting them to assess the astronaut's condition. If necessary the medical men—one at each telemetering station—can notify the control center at Cape Canaveral of the desirability or need to abort the mission. Scheduled or emergency recovery of the manned capsule will be carried out by Navy ships picketed at preselected areas.

• **Recovery operation**—Firing of retrograde rockets will slow the capsule and return it to atmosphere, about 70,000 ft up. Then a series of parachutes will further slow the descent and give the recovery ships ample time to determine where the capsule will land and to converge on the impact point.

Planned impact point, at the completion of the third orbit, is off the coast of San Salvador. The map (page 19) shows the orbital paths (determined by the direction of launch) and some stations in the range. As the capsule flies over Hawaii on the third lap, a tracking station there will send to the computing center final information for correcting predicted trajectory. When the capsule is several hundred miles off the U.S. west coast, retrorockets will be triggered. The preset program for retrorockets fixing will be carried by the capsule.

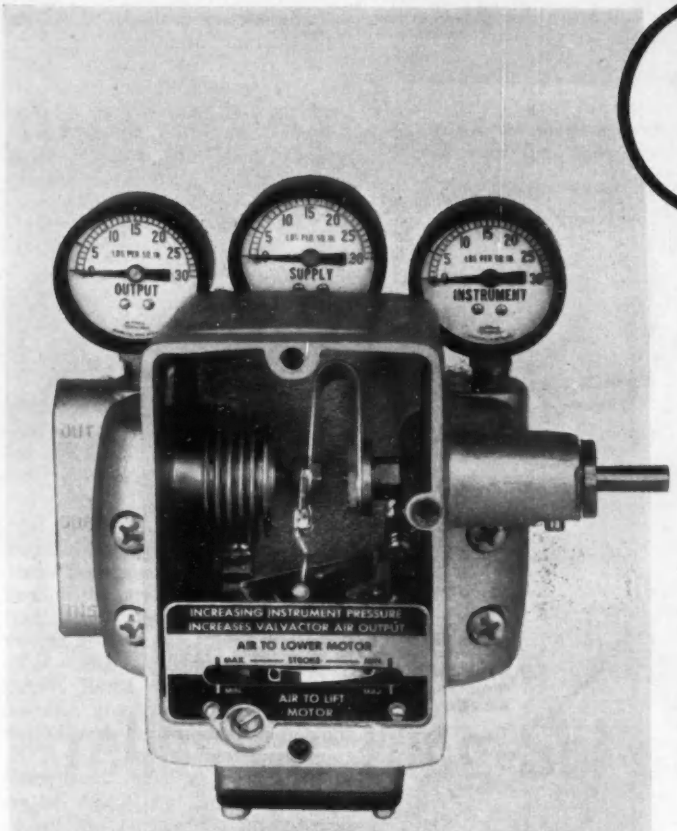
The orbital paths crossing near the Florida coast establish a high-probability recovery area should conditions require aborting the mission prior to completion. Abort and recovery of the manned capsule will occur in case of failure of life support system, attitude control, or power supply, in case of cabin decompression or fire, or in case of pilot's physiological or psychological difficulties.

• **Range arrangement**—In the general range plan, the tracking network determines vehicle location, the telemetry and communication system monitors the status of vehicle and occupant, and the computing and control centers initiate command functions for abort control and normal reentry initiation.

In all, the range will be made up of 17 primary stations; seven already exist as parts of the Atlantic, Pacific, and White Sands missile ranges. That leaves only six telemetering and four tracking stations to be built. These new stations will be mobile to offer flexibility in positioning stations for future tracking missions. The heavy concentration of tracking capability in the U.S. permits precision determination—from present data—of future capsule position. This type of prediction will be carried out by a

the Foxboro Type C VERNIER VALVACTOR*

MOST UNIVERSALLY ADAPTABLE VALVE POSITIONER ON THE MARKET!



The Type C Valvactor's distinctive motion-balance principle of stem positioning eliminates loading effects of heavy fixed-stroke actuating springs. Note compactness — the simplest mechanical design of any valve positioner.

*Trademark of a precision valve positioner made by The Foxboro Co.

Unique Flexibility Easily reversible in seconds. Sequencing by two simple adjustments.

Super Response Full air-pressure output to diaphragm motor on signal air-pressure change as small as ½ of 1% of signal span.

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Positive Positioning Direct, motion-balance feed-back assures instantaneous, pin-point positioning.

Now there's a positive-action, super-precision valve positioner that you can easily adapt to any diaphragm motor application — without exchange of parts! It's the Foxboro Type C Vernier Valvactor with unique motion-feedback.

The Type C Valvactor has a master setting disc which provides easy change of action as required by the control system, as well as easy reversal of Valvactor action for air-to-open or air-to-close control valves. Adjusting for limited stem travel is equally simple ... sequencing of several valves is a cinch!

The Valvactor is the ideal solution to such problems as stem friction, plug friction, valve motor and transmission line lag, and extreme process line pressure changes. And it requires practically no maintenance! Available with 3-gauge and by-pass manifold, or plain manifold. Write for full details.

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CIRCLE 19 ON READER-SERVICE CARD

group of computers in the Washington area.

• **Communication and computing**—A survey showed the best location for the computing and communications center to be Washington, because of the extensive communications facilities already existing in that area.

Communication to the computer will be by land lines or submarine cable from stations in the U. S. and Hawaii. Bermuda station will have a separate computer and will act independently if its radio link with the center fails. Other stations, sending data by teletype, will not be in real-time communication with the center.

The computing and communications center will collect data from tracking and telemetering stations, compute trajectory, and provide the control center at Canaveral with information needed for its control-command recovery functions. Digesting tracking data, the computing center will determine at what instant to fire the retrorockets either for normal or abort reentry to bring the capsule down in a selected recovery area; another job is to supply acquisition data for the next radar along the capsule's path.

• **Control center**—At the Cape Canaveral control center, the mission will be masterminded. Into the center will flow information from the computing and communications center, from the launch pad, from computers, and from various receivers. And from it will go command signals to the capsule. Displays will indicate trajectory data, impact prediction, time to retrofire, range status, capsule data, and aeromedical data. With such information at hand, control officers can make necessary decisions about mission progress and initiate appropriate commands.

What happens if the retrorockets don't fire? Here, too, NASA has anticipated the contingency. At the selected orbit altitude—105 miles—enough friction exists to slow the capsule down and return it to atmosphere in 48 hours. And this will be enough time to predict impact point and start moving recovery units to that location.

—Harry R. Karp

•

Airborne statistical telemetry equipment will be supplied by Applied Science Corp. of Princeton for Project Mercury. The $100,000 installation will consist of a dual channel spectrum analyzer: one channel for the airborne analysis of vibration data; the other for acoustical data. By analyzing the noise spectrum in space, bandwidth requirements are reduced from several kc to near zero.

Cutler-Hammer's new sensitive, heavy-duty transistorized relay. The Tung-Sol germanium transistor, power type 2N379, is at the center of the plug-in module, electronic heart of the relay.

New versatile CUTLER-HAMMER CONTROL C-H relay relies on Tung-Sol semiconductor

Tung-Sol semiconductors furnish the combination of sensitivity and ruggedness needed for Cutler-Hammer's new transistorized relays. The Tung-Sol units react quickly and display unfaltering electrical stability. They resist shock and vibration, and stand up under the most severe industrial service.

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If you need the power-saving, space-saving features of semiconductors . . . if your circuit calls for tubes — you can be assured of premium performance when you specify Tung-Sol. Tung-Sol makes both to a single high quality standard. Our applications engineers, expert in both vacuum tube and semiconductor problems, can give you an impartial recommendation for the circuit complement that most efficiently answers your design needs. Tung-Sol Electric Inc., Newark 4, New Jersey.

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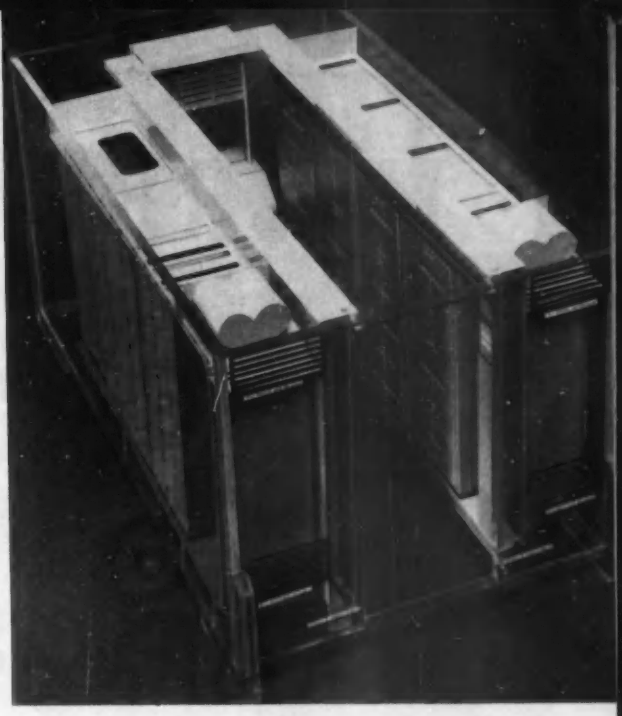
The Army's Newest Weapon: *ADP*



Dummy model of Informer, intelligence computer being developed for the Army under the eye of Fort Huachuca's Automatic Data Processing Dept.

Computers may become regular issue for tactical units of the Army. A program is underway to develop ruggedized mobile machines and to search out applications of automatic data processing.

FORT HUACHUCA, ARIZ.— How can the tactical army use computers? What functions of an army command lend themselves to ADP (Automatic Data Processing)? What kind of computer hardware is needed to satisfy the rugged requirements of Army life? These three problems are the backbone of a giant data processing project at the Signal Corp's Fort Huachuca electronic proving ground. Later this month, Huachuca computer men will make one of several detailed proposals to CONARC (Continental Army Command), which is coordinating the army's overall effort, suggesting specific ways and means of using computers in the tactical army.

Since 1956, the Signal Corps at Fort Monmouth (N. J.) has wrestled with the problem of where to look for applications of ADP. The Corps, with CONARC, has queried all the branches of the tactical army, producing some 70 suggestions.

Huachuca's Automatic Data Processing Dept., is now following up this early work. Its main effort: preparing possible computer programs. In addition, the department is performing systems analysis and trying out the programs on simulated versions of the field computers.

Lt. Col. J. F. Nutt, head of the Field Test Div. of the ADP Dept. points out that some army applications don't lend themselves to automatic data processing. But the group is studying almost 100 promising possibilities which do. Example: the artillery field survey—determining what guns are in range of a target; calculating how much ammunition each gun has left, how much life each gun barrel has remaining so that a commander can decide which guns to fire.

Right now, Huachuca's major activity is in two directions: first, with systems management help from the Ramo-Wooldridge Div. of Thompson Ramo Wooldridge Inc., the ADP Dept. is readying to test a family of field computers for the army; second, the department is testing army field applications of automatic data processing. Final decision on the third aspect —at what levels computers will be used—is up to CONARC which is coordinating army's computer efforts.

• **New computers**—Hardware studies are well underway. In fact, first delivery of a prototype is expected before the end of the year. There are four machines in the field family:

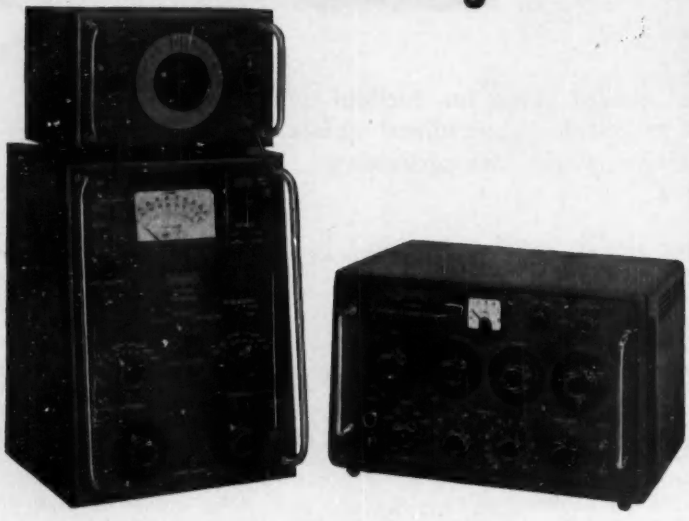
▶ MOBIDIC (Mobile Digital Computer) is probably the best known. It's a general purpose, solid state machine with about the same capacity as an IBM 709, although it is being built by Sylvania Electric Products, Inc. Its core memory can be expanded to a capacity of 28,000 words. Huachuca's ADP Dept. thinks that MOBIDIC, mounted in two trailer vans, will probably be employed at Army headquarters level (organizationally, an Army is composed of two or more Corps; each Corps is made up of three divisions) to do a wide variety of functions. Some typical ones: automatic compilation of reports such as the army's traditional morning report, bookkeeping and record keeping for troop payments, logistics controls—automatically telling when to order key supply items, and cataloging intelligence and tactical information.

Although the Army commander still has to make tactical decisions, once such a decision has been made, the computer can be put to work to supply logistic data to help implement the decision.

▶ LOGIPAC and BASICPAC are quite similar in design. Both are being constructed by Philco Corp.; both are transportable in 2½ ton truck shelters. They are intended for command posts at a lower level than the Army headquarters. The bigger storage capacity of LOGIPAC makes it look promising for depot warehousing ac-

MUIRHEAD

Transfer Function Analyser



The Muirhead Transfer Function Analyser is an easy-to-operate equipment which provides an accurate method of testing the frequency response of servo systems and electrical networks.

The Analyser will measure the phase difference and amplitude gain or loss between any two points of a servo system over the frequency range 0.5c/s — 10kc/s. From this data, the Transfer Function of the system, or any of its sections, can be computed.

Results are obtained directly in polar form so that polar diagrams (e.g. Nyquist diagrams) can easily be plotted.

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CIRCLE 22 ON READER-SERVICE CARD

WHAT'S NEW

counting operations.

▶ COMPAC is also a Philco project and it is a derivative of the LOGIPAC design. But it is to be a small (2½ cu. ft), portable (85 lbs) machine that would be used at special sites—as part of a radar or a meteorological system.

One other machine being developed is not part of the family of field computers. This device is called Informer, and it is being built by IBM. As its name implies, Informer has an intelligence job. Its main function: to store a huge volume of facts about the enemy and make them easily accessible on call. It will be a general purpose machine with special purpose search devices. Its large random access file will hold 200,000,000 bits.

To back up these computing machine developments, the Army is also pushing work on new peripheral equipment.

• Anderson Nichols is producing an electromechanical, ruggedized high speed printer with a capability of 600 lines per min.

• Smith Corona Kleinschmidt is building a ruggedized input-output device. Input may be punched in by keyboard or by punched tape.

• Ampex is designing a special military tape transport unit which will not require rigid humidity and temperature restriction controls. Its characteristics: a 45 kc rate, 500 bits per inch packing, and a tape speed of 150 in. per sec.

• **Systems analysis**—Some of the most interesting work underway on the computer project is the digital simulation being done on both equipment and systems. According to Capt. A. B. Crawford, Operations officer of the Huachuca ADP Dept., a possible application of MOBIDIC is tried by simulating MOBIDIC on another computer and then debugging the program for the application right on the simulated MOBIDIC.

For this digital simulation work, Fort Huachuca dedicated in February one of the most extensive computing facilities in the West. The base has a new IBM 709 machine, a Librascope LGP 30, an Autonetics Recomp II and an IBM 610.

But even with the most detailed simulation, the final proof of the usability of a computer and an automatic data processing system will come from actual field tests which Fort Huachuca is now setting up to handle. Huachuca will be a proving ground for computers and ADP systems just as Aberdeen tests artillery guns.

—Lewis H. Young

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In addition to giving visual warning to the operator, the NLS 50 gives go/no-go commands to such electrical devices as cut-off relays, sorting chutes, data printers, tape or card punches, and audible warning equipment. Extremely versatile, the instrument may be used as a high-accuracy voltmeter without modification and may be adapted easily to detect resistance limits.

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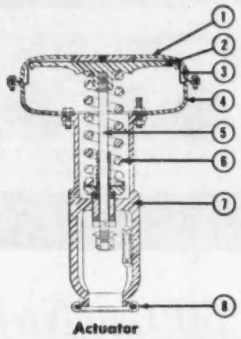
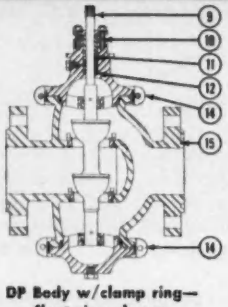
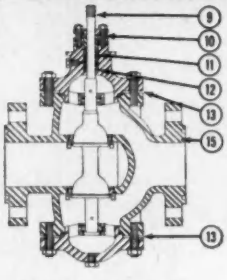
BS&B Super 70 Control Valves are widely used with instruments to control pressures, temperatures, liquid levels and flow. They efficiently handle gas, air, vapor, steam or liquids in a wide variety of applications. Valve bodies are available with either the patented clamp ring —float ring closures—up to 600# ASA— or the conventional flanged-gasketed type closures in ratings up to 2500# ASA.



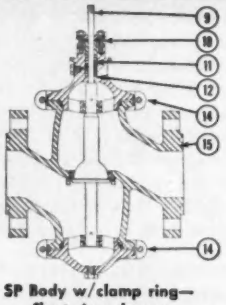
Actuator



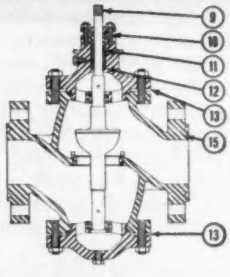
DP Body w/clamp ring—float ring closure



DP Body w/flanged-gasketed closure



SP Body w/clamp ring—float ring closure



SP Body w/flanged-gasketed closure

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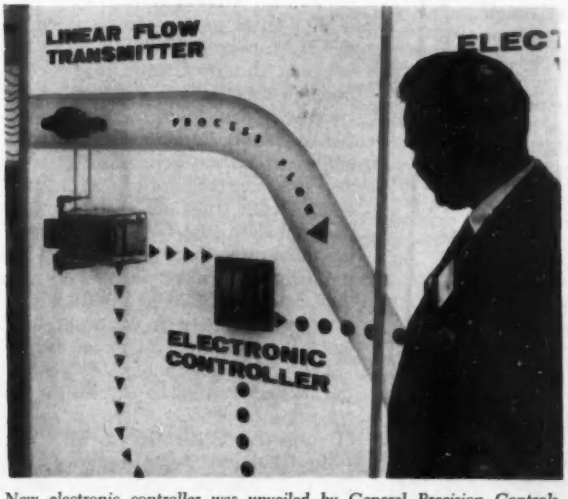
CtE Visits the World Petroleum Congress

Oil men from all over the world flocked to New York for the Fifth Annual World Petroleum Congress, first ever held in the U. S. Mirroring the increasing importance of control, many of the most interesting booths exhibited control products. The three key areas: adapting computing-control to the process, extending sophisticated electronic controls into the oil fields, and presentation of new, unique measuring instrumentation.

Mass Flowmeter for natural gas was jointly developed by Black, Sivalls & Bryson and General Electric Co. Reading directly in pounds, the unit measures the angular velocity imparted to the fluid as it flows through a turbine. The torque, proportional to this angular momentum, is transmitted to a gyro-integrating mechanism which transfer the mass flow into a cyclometer register where it is recorded in pounds. Production of the unit for gas applications is scheduled to begin in 1960.

Supervisory Control, offered by Texas Instruments, uses 16-bit code word for measurement, control and alarm on a single pair of wires or microwave. Units are available as all-solid-state, all-relay, or any combination. Installations already sold: automatic custody transfer applications, and automatic, remote control of off-shore drilling stations. Venezuela Sun Oil's installation on a drilling platform in the middle of Lake Maracaibo will be one of the most sophisticated applications of electronic control in the oil production industry. Magnolia Oil Co. will use its system for automatic custody transfer.

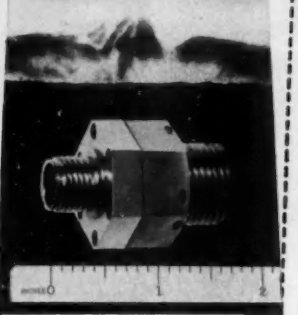


New electronic controller was unveiled by General Precision Controls, Inc. in display that preached all-electronic approach to process control. It included linear flow transmitter, electronic controller, electro-hydraulic actuator and general purpose digital computer (Libratrol 500).

Established product with new application was this Product Analyzer built by Industrial Nucleonics Corp. and now being applied to petroleum processes. Under development by the same company: a portable radiation density gage for use in oil fields.

FOR
ROCKET ENGINES

ACCURACY
IN SPITE
OF
BLAST



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ENGINE
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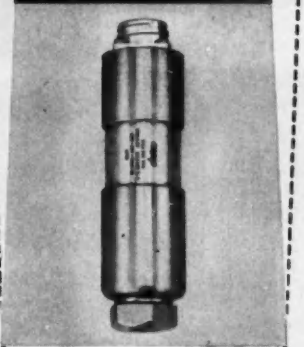

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In automatic transmission pressure tests run by one of the world's leading auto manufacturers, this rugged pressure transducer has outlived engine after engine throughout more than two years of 24-hour-a-day test operation. Built to stand rough handling and mechanical overload in many applications, the P10 affords the accuracy, reliability and infinite resolution of an unbonded strain gage instrument. Write to Dept. CE-604-1

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CIRCLE 25 ON READER-SERVICE CARD

WHAT'S NEW

NEMA Systems Section . . .

. . . gets underway with a full head of steam. Task forces start meeting to develop standards for industrial automatic systems.

Since its formation in January (CtE, Feb. 1959, p. 28), NEMA's (National Electrical Manufacturers Association) new Industrial Automatic Systems Section has moved fast to set up working task forces. Reporting on the first six months activity, Section chairman D. L. Pierce, (Westinghouse Electric Corp.) said that the group now has ten member companies:

Allen-Bradley Co.
Allis-Chalmers
Clark Controller Co.
Cutler Hammer
Electric Corp. of America
General Electric Co.
Reliance Electric and Eng. Co.
Square D Co.
Ward Leonard Electric Co.
Westinghouse Electric Corp.

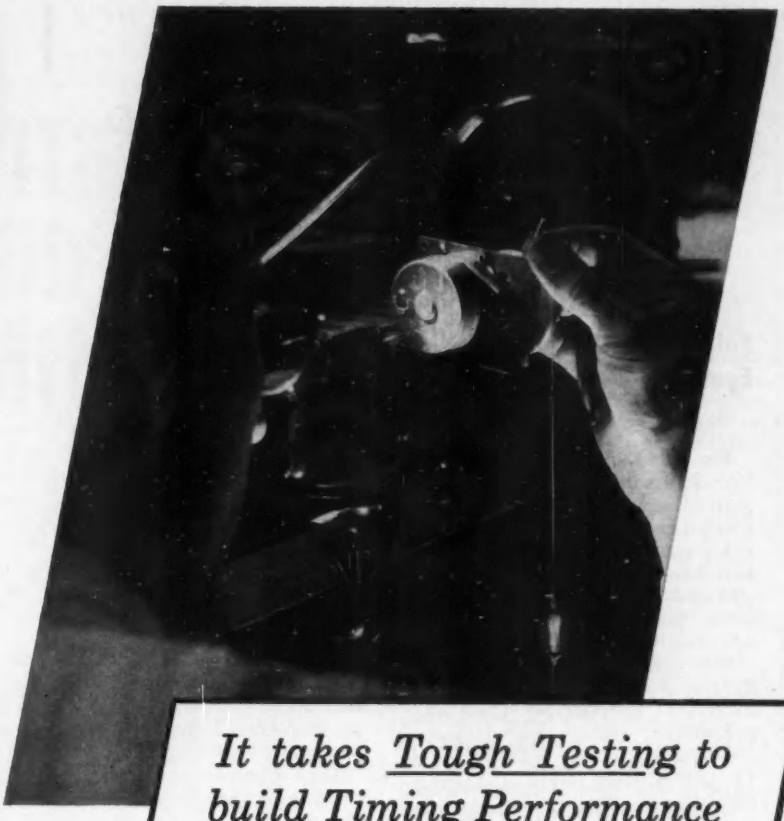
At the first meeting back in January, said Pierce, a General Engineering Committee was formed (Its chairman: William Alvarez, GE) and instructed to establish standards including the following specific areas: 1) definitions; 2) compatability of system components; and 3) standards for system performance.

In February two task forces were set up. One is working on definitions, reviewing all existing and proposed definitions concerning automatic systems and components. Its chairman: R. N. Eck (Cutler-Hammer). The second; on system compatibility.

The latter group, chairmanned by A. G. Mueller (Square D Co.), is developing utilization standards for components used in industrial automatic systems. That means rating utilization standards, performance standards, voltage utilization standards and standards for acceptable forms such as tape widths, card sizes and codes.

Meanwhile, the General Engineering Committee itself has attacked the problem of standard voltages for systems below 110 volts and standards for a range of operations in the areas of voltage, temperature and frequency.

One other group hard at work is the Scope committee which is attempting to define the section's areas of interest. Chairman H. W. Cory (Allis-Chalmers) cites the need for the new, NEMA section in a special editorial on page 79.



It takes Tough Testing to build Timing Performance

When you buy a Haydon Timing Motor or Timing Device, you buy high quality and superior performance, because every production model and every new design has *proved* itself by passing the toughest, most exhaustive series of tests that our engineers can devise.

Quality control at Haydon starts with a careful inspection of all in-coming materials. It continues throughout production — with all parts and assemblies gaged, inspected or physically tested after every operation that can affect the performance of the finished motor or device. Final step is an inspection of completed motors and timing devices. All units are performance tested for many hours under varying conditions and are checked for quiet operation. Percentage samples of each lot are checked for torque rating, timing accuracy, and accuracy and alignment of gears and shafts. In addition, all new designs and periodic samplings from production are subjected to special "life endurance" tests in which hundreds of units are run continuously under various load conditions. In some instances, units have now been running ceaselessly for more than 10 years . . . proving their ability to perform *millions of cycles without failure!*

When you submit your timing problems to Haydon, you can be certain that our teams of engineers and other Timing Specialists have the experience, knowledge and facilities to supply devices designed, produced *and* tested to meet your needs exactly and perform according to your specifications.

For further information, write now, outlining your timing requirements.

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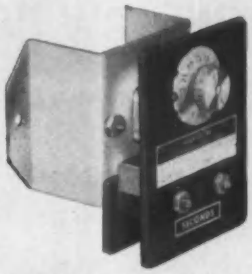
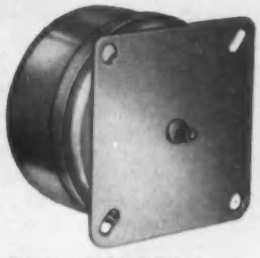
Headquarters for Timing



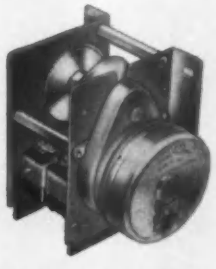
TIME DELAY TIMER

Provides time delay in ranges up to 9.5 minutes. Ideal for such applications as the protection of power tubes and/or operating preset operating cycles. Available in 120 or 240 volt, 50 or 60 cycle current.



400 CYCLE MOTOR

These split phase motors provide the military an accurate approach to timing control for military applications. Rotor speed is 3,000 RPM at 400 cycles, 115 volt normal. Two models are available — Heavy Duty with 18 gram millimeters torque at the rotor, and the Miniature with 5 gram millimeters at the rotor. These motors may be applied to Haydon gear trains if desired.

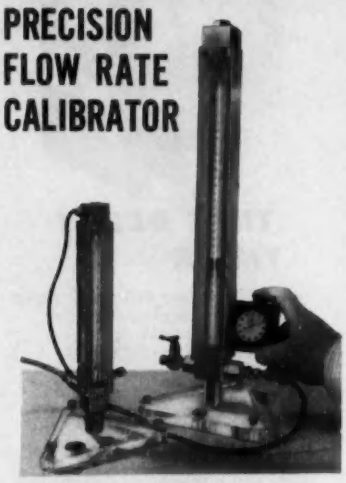


CYCLE TIMER

These units repeat a set cycle or sequence of operations as long as the motor is energized. Available in a wide choice of speeds, a broad range of timing intervals, and with a wide range of enclosed single pole, double throw switches for 120 and 240 volt operation, for 50 and 60 cycles.

CIRCLE 26 ON READER-SERVICE CARD

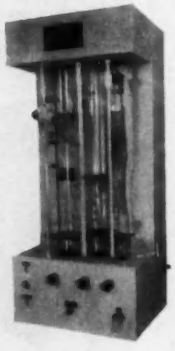
NEW LOW-COST PRECISION FLOW RATE CALIBRATOR



Now, with a low-cost Porter Volumetric Calibrator,* you can easily and accurately calibrate any fluid-flow device. Far simpler to use than other equipment presently available, this calibrator requires no vapor-pressure corrections or involved mathematical computations; its operation can be quickly mastered by even non-technical personnel.

The primary element of the unit is a free-floating piston which rides within a precision-bore glass tube. A unique "mercury-ring" seal gives the piston nimble responsiveness, yet prevents error-inducing leakage. Back-loading is extremely low, and is constant throughout the full range of piston travel.

Sizes from ½" to 5" with capacities from 25 cu. to 0.75 cu. ft. are available.



Portable Flow Rate Calibrator, Model No. 1050, is a complete, packaged test stand for ranges from 50 to 5000 cc/min. Unit has three precision-bore calibration chambers, a back-pressure indicator, gas temperature indicator, automatic overrange protection, automatic timer, and all necessary selector and dump valves.

*Pat. Pend.

WRITE FOR DETAILED INFORMATION

BROOKS ROTAMETER COMPANY

759 E STREET, LANSDALE, PA.

O-A. 1936

CIRCLE 27 ON READER-SERVICE CARD

Control Meeting Roundup

- *What's next in telemetry?*
- *Unraveling self-organizing concepts*
- *Big savings for gas from instrumentation*

Telemetry Conference Eyes the Future

DENVER—

For the National Telemetry Conference, traditionally a place for reports of past achievements, 1959 was a major change. Much of the material presented had a future completion date. Listeners kept hearing references to "the next thing to be done" rather than detailed descriptions of what has been done.

One significant accomplishment for the future was the founding of a Joint Technical Telemetering Conference Committee, aimed at coordinating every interest in the field. Gus M. Thynell, Applied Physics Laboratory, Johns Hopkins Univ., was appointed temporary organizing chairman.

Organizations to be represented at the start: American Rocket Society, American Institute of Electrical Engineers, Institute of Aeronautical Sciences, and Instrument Society of America. Later, the Institute of Radio Engineers will be invited to join (IRE is the only major society which does not participate in the NTC; it has its own telemetry conference).

• **Tomorrow's telemetry**—The future of telemetry came in for particularly careful scrutiny at one panel session. Speakers agreed that the next major step would be a closed loop system operating at command.

"About 99 percent of telemetering now is 'just in case' information", said Lawrence W. Gardenhire, director, astrionics div., Radiation Inc. "The best way to avoid this is to establish a flexible command system that will record data only when needed."

Telemetry will cease to exist in its present form in the next few years, Gardenhire predicted. "As we go out further into space," he said, "we must combine all types of measurements into a common system that will include guidance—a two-way control system operating at command".

• **Space data transmission**—At another panel session, speakers took a look at space data transmission and its future. Dr. George E. Meuller predicted improved worldwide telephone service, radio, and television reception in five or ten years through "fixed" satellites. Serving as repeater stations, these satellites would be so far out in space—22,000 miles—that they would be synchronized with the earth's rotation.

Dr. Meuller had some other ideas for better communications, too. He urged the installation of digital systems in satellites soon. The use of digital techniques, he said, will simplify data reduction on the ground.

Both Dr. John Hagen, National Aeronautics and Space Administration and Dr. William H. Pickering, Jet Propulsion Laboratory, urged simple space experiments. Hagen said "One of the best ways to insure success is to lay tremendous emphasis on the simplicity of the experiment". Pickering added, "The lesson we have learned from the past is this: keep things simple and you have a better chance of getting useful data".

• **NTC attendance booms**—The futuristic aspects of the 1959 conference apparently had a beneficial affect on the registration desk. 1,063 engineers attended, a big increase over the 600 at the 1958 meeting in Baltimore.

—Frank Pitman
McGraw-Hill News

Disciplines Clash at Self-Organizing

CHICAGO—

When the sponsors—Armour Research Foundation and the Office of Naval Research—organized the Interdisciplinary Conference on Self-Organizing systems, they had a clear objective in mind. They expected that discussions of "growing (meaning evolutionary) automata", devices capable of a lot of learning or self-organizing, would shed cross-disciplinary light on how to design and engineer such spontaneous operations.

But the hope for cross fertilization was slow to materialize. In the broad gage meeting, the disciplines found it hard to "inter-anything". Babel and confusion reigned as medical doctors

A VITAL 100 MINUTES!

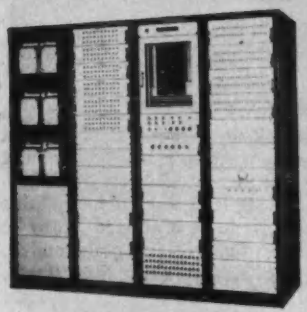
Firing Sequencer with 762 CLARE RELAYS gives automatic control

Automatic control of the countdown at the Air Force's Cape Canaveral Missile Test Center—from X minus 90 minutes to 10 minutes after a missile is fired—is in the hands of a Milgo Model III Sequencer.

The Sequencer, built by Milgo Electronic Corporation, Miami, Fla., automatically controls the myriad operations which must be performed before any missile can be launched. It is preprogrammed to recognize the precise condition that must exist during each of the operations it controls. When any other condition is detected, it will automatically hold fire until the condition is corrected. In a recent instance, it saved a Titan prototype which developed a malfunction after firing but before actual takeoff.

Another of these sequencers is being built by Milgo for installation at the Pacific Missile Range, Vandenberg Air Force Base, Calif.

Milgo engineers selected 762 Clare Type J and Type HG Relays for this supremely important device, and not one has ever malfunctioned. Here is convincing proof that, where the safety of personnel and of valuable equipment is at stake and the utmost accuracy is demanded, a designer who rides with Clare relays can rest assured that he has chosen wisely and well,—not necessarily the cheapest relays but certainly the very best.



Front view of Model III Sequencer which uses 762 CLARE Type J Relays and 14 CLARE Type HG Relays. Made by Milgo Electronics Co., Miami, Fla.

View of control rack of Model III Sequencer showing 56 CLARE Type J sealed relays.

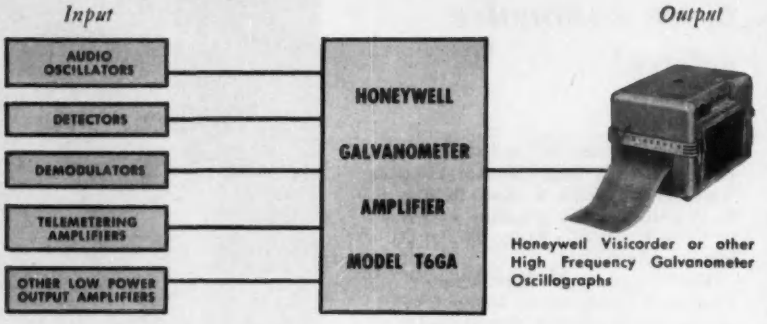
CLARE RELAYS

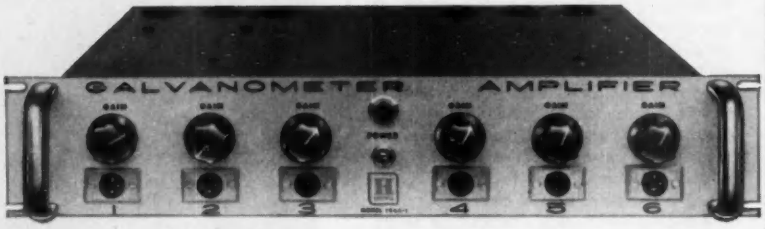
C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Il
In Canada: C. P. Clare Canada Ltd., P. O. Box 13 , Ontario.
Cable Address: CLARELAY

CIRCLE 28 ON READER-SERVICE CARD

NEW GALVANOMETER AMPLIFIER

Strengthens Low Power Signals to Drive High Frequency Oscillographs





Galvanometer Amplifier, Model T6GA-1, measures 3½" high, 19" wide, 15½" deep.

DESCRIPTIVE DATA

VOLTAGE GAIN:
Adjustable from 0 to 1.0

OUTPUT (37 OHM LOAD):
±2.4 volts at 65 ma d-c to 8 Kc, limits at ±100 ma.

OUTPUT IMPEDANCE:
2 Ohms d-c to 10 Kc

CONTROLS:
6 GAIN controls, 1 Power ON-OFF switch

INPUT IMPEDANCE: 47 K

ISOLATION:
Individually floating channels for use with ungrounded loads

NOISE:
Less than 3 mv peak-to-peak

DRIFT:
Less than 3 mv/°F

POWER REQUIREMENTS:
115 volts ±10 volts, 50 to 440 cps, 45 watts

With Honeywell's new Galvanometer Amplifier, Model T6GA-1, high frequency oscillographs can now be operated directly by low power input sources of 1 volt or more. These inputs, some of which are shown in the diagram above, should have output impedances of 10 K or less although higher source impedances can be tolerated. Noise and drift are indistinguishable on the recorded output when the galvanometer-amplifier combination has a maximum sensitivity of 1 inch per volt.

The Model T6GA-1 is a compact, six channel, three stage transistor d-c amplifier with overload protection to eliminate both danger of transistor damage and galvanometer burnout.

Each of the six amplifier channels is isolated from ground by individual floating power supplies. Write for Bulletin B-ET6 to Minneapolis-Honeywell, Boston Division, Dept. 34, 40 Life Street, Boston, Mass.

Honeywell

H HONEYWELL First in Control

CIRCLE 29 ON READER-SERVICE CARD

WHAT'S NEW

tried to talk to computer doctors, control doctors, logic doctors, language doctors, and natural historians—and vice-versa.

One common stimulus, however, was the push to develop systems which can spontaneously (or automatically) classify, identify and represent their inputs and states. Systems that will identify written and spoken symbols, translate language, retrieve information and adapt themselves to prescribed goals, must have such spontaneous abilities.

Although ideas and philosophies abounded, hardware and specifics were as scarce as the desired interdisciplinary accord. One exception was a presentation by Gordon Pask, English scientist currently visiting at the University of Illinois. Pask described an electrochemical device that actually duplicates what PhD's and MD's believe the learning process does.

• **Common concept**—In the divergence of ideas, one thought kept reappearing. Any self-organizing system must have a "training sequence". By training sequence, speakers meant some activity by which the system could look at its own response and remember whether it was good or not for future use.

The thing (as good a name at this time as any) to be organized has to be described, that is its goals stated, methods of accomplishing them stated, and priorities assigned to the methods. If no priority sequences are assigned, a circumstance called "pandemonium" takes over.

• **Feedback applies**—It was interesting to control engineers to realize how the idea of "feedback" generalizes to fit the postulates of the self-organizers. Logic devices take the differences between goals and performance, find a given characteristic and direct the actuators.

But a lot of questions remain. How formal, how finite, how nearly fixed must a system be before self organization, self improvement or spontaneous construction will go to work? And what stops it once it has started?

—William E. Vannah

Instrumentation Payoff in Gas Transmission

DALLAS—

Economic justification of telemetry, remote control and information systems proved to be the highlight of the American Gas Association Transmission Conference held here in May. Listeners heard reports of big savings

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VICKERS®

SILICON POWER RECTIFIERS

SOUND ENGINEERING • PRECISE MANUFACTURE • THOROUGH TESTING

assure

GREATER RELIABILITY • CONSISTENT QUALITY • LONGER LIFE *AT LESS COST*

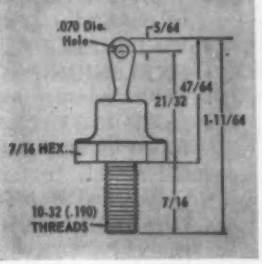
Every Vickers Silicon Power Rectifier offers the same excellent operating characteristics: extremely low reverse current and forward drop; stability at high temperatures; greater economy, with current ratings as much as 25% above other rectifiers of similar size and price.

This uniformity is achieved through stringent manufacturing and quality control techniques, with "surgical" cleanliness at every stage of production. Uniformity in manufacturing produces higher yield of perfect rectifiers at minimum cost to you. Uniformly high product quality means exceptional reliability—low maintenance costs.

For complete information on Vickers Silicon Power Rectifiers, available in 2, 8 and 12 ampere sizes, contact the sales engineering office below, or write for Series 3300 Bulletins.

VOLTAGE	CATALOGUE NUMBERS		
	2 AMPERES	8 AMPERES	12 AMPERES
100 V	AA 10	BA 10	CA 10
200 V	AA 20	BA 20	CA 20
300 V	AA 30	BA 30	CA 30
400 V	AA 40	BA 40	CA 40
500 V	AA 50	BA 50	CA 50
600 V	AA 60	BA 60	CA 60

DIMENSIONS



ELECTRIC PRODUCTS DIVISION — VICKERS

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CIRCLE 30 ON READER-SERVICE CARD

WESTINGHOUSE HEAVY-DUTY PROXIMITY LIMIT SWITCH

- WON'T WEAR OUT . . . completely static, never needs to be replaced
- WATERPROOF . . . operates completely submerged in liquid
- EXPLOSION-PROOF . . . new Westinghouse switch is "potted" . . . all internal connections are completely sealed
- CUTS INSTALLATION TIME . . . trip point is easily adjusted by balance adjusting screw . . . no contact or lever arm adjustment
- CORROSION RESISTANT . . . impervious to salt spray
- DESIGNED FOR MILITARY APPLICATIONS . . . has passed military shock and vibration tests
- TWO SENSING HEADS AVAILABLE . . . for either tripping distances within ½ inch . . . or within 2 inches

Why not get all the facts about the new Westinghouse heavy-duty proximity limit switch . . . see how and where it can save you time and money and give you a better job. Contact your nearby Westinghouse sales engineer. Or, write Westinghouse Electric Corporation, Director Systems Department, 356 Collins Avenue, Pittsburgh 6, Pennsylvania. J-01017

YOU CAN BE SURE...IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

CIRCLE 31 ON READER-SERVICE CARD

made possible by installation of telemetering and remote control gear.

For example, as a result of one installation, C. E. Pettry, Charleston Group Cos., Columbia Gas System, Inc., reported estimated annual labor savings of $150,000—exclusive of fringe benefits which add on an additional 20 percent. The system, which continues to grow in size, now ties in 22 stations telemetering 171 operations to two central control points. Eventually it will telemeter 250 pressures from 50 stations, remotely operate necessary valves and regulators.

"We are becoming more convinced each day," Pettry concluded, "that this is the best way to handle large volumes of gas efficiently and economically".

Remote control operation of a marshland gas station will pay off in three years, B. O. Fields, Southern Natural Gas Co. told the meeting. Because the station is located in an area normally inundated with several feet of water, the major saving stems from not having to build quarters for an operating crew.

The station is remotely controlled by a microwave system consisting of two terminal stations and one repeater station. Information such as pressures, temperatures, engine speed and valve positions is telemetered to the control station located 45 miles north of the station.

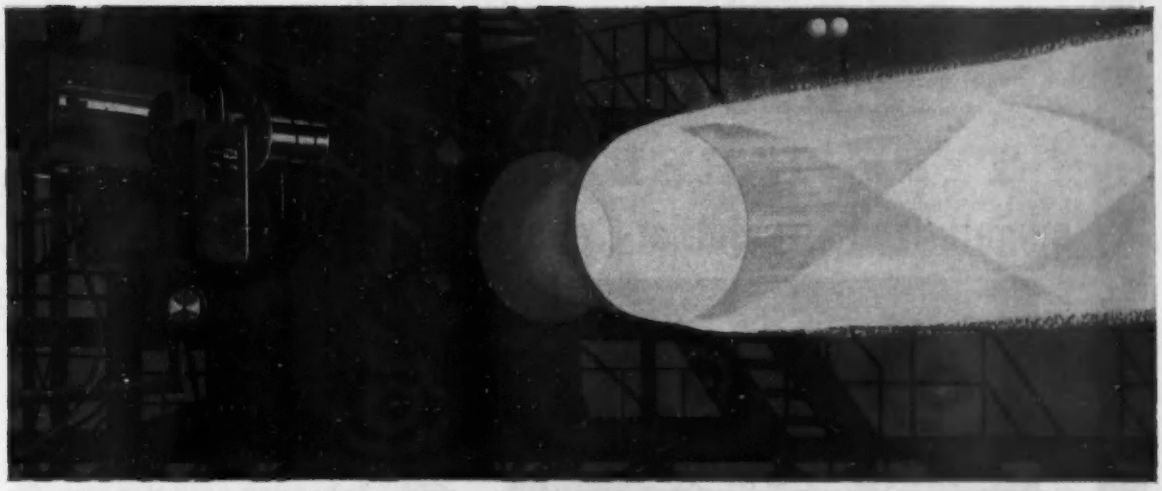
—Kemp Anderson
McGraw-Hill News

Purdue-CtE Conference: A Tutorial Success

LAFAYETTE, IND.—Over 100 industrial control engineers registered for the first Purdue-Control Engineering Components Conference, held at West Lafayette, Ind., May 4 and 5. The specially prepared papers—on the theme, Putting Control Components to Work—prompted a lively discussion period after each presentation. Five of the outstanding papers will be published in future issues of CtE.

Main banquet speaker, J. Allen Crocker (program director, guidance and control, Office of Advanced Technology, National Aeronautics and Space Agency) proved to be a talented speaker as well as a valuable source of information. His review of how component failures have haunted missile and space shoots gave the audience of industrial control engineers a taste of military problems.

To see where man cannot survive...



Convair–and hundreds of other firms–use KIN TEL Closed Circuit TV

CONVAIR, NORTHROP, LOCKHEED, DOUGLAS and virtually all other major missile and aircraft manufacturers use KIN TEL closed circuit TV to observe operations that are tedious, difficult, or even impossible for men to watch.

Other industries, too, rely on KIN TEL TV to perform a countless number of jobs safely, inexpensively, tirelessly. U. S. STEEL uses it to see inside open-hearth furnaces. WESTINGHOUSE watches nuclear power-reactor tests with it. AMERICAN POTASH AND CHEMICAL uses it to monitor production-line and warehousing operations. All told, hundreds of companies – both large and small – have found profitable uses for this equipment.

KIN TEL's basic TV system, consisting of camera, camera control, and receiver, is surprisingly low in cost, and may be obtained on a lease-purchase plan. The camera is rugged, compact. Picture quality is almost twice that of the best home TV reception. A complete line of housings and accessories permits observation of nearly every kind of operation, in all kinds of environments.

Nationwide factory-trained engineering representatives can show you how KIN TEL TV can be put to profitable use in your company. Write direct for TV catalog 6-103 and the name of your nearest representative.

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KIN TEL
A DIVISION OF
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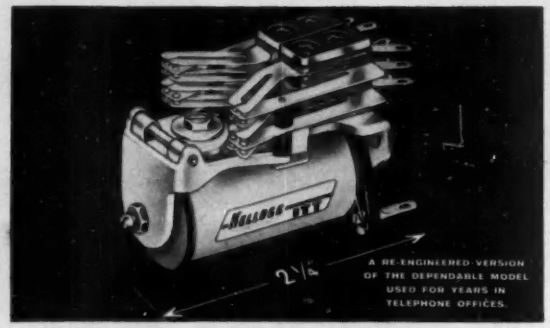
KIN TEL–pioneer and leader in television systems for industry.

KELLOGG

TYPE "L" RELAY

miniaturized • versatile • reliable



Kellogg's Type "L" Relay features—

High operating force: greater sensitivity, gram pressure, springs per pileup.

Rear mounting: for ease of wiring.

Wide coil variety: single or double wound, for any circuit needs.

Bifurcated stationary springs: for independent contact action and high reliability (single contacts also available).

Heavy duty bronze yoke and stainless steel bearing pins: for long life and stable adjustment.

Single or double arm type armatures available.

Hermetically sealed models, if desired.

Operating speed: minimum of 1-2 milliseconds.

Contact points: gold, silver, palladium, tungsten; others available.

Residual: adjustable and fixed.

Time delay: heel-end slugs and armature-end slugs for release time delay and operate time delay, respectively.

Terminals: slotted.

Weight: net, 2-1/4 oz.

Dimensions: 2-1/4" L x 1-1/8" W, height ranges from 17/32" to 1-1/16" (max.)

Operating voltages: up to 220 volts D.C.

Backed by Kellogg and International Telephone and Telegraph Corporation. Inquiries are invited. Send for a free catalog on Kellogg relays, components.

KELLOGG Communications Division of IT&T
CHICAGO, ILLINOIS

Kellogg Switchboard and Supply Company, 6650 South Cicero Avenue, Chicago 38, Ill. Communications division of International Telephone and Telegraph Corporation.

Manufacturers of Relays • Hermetically sealed relays • Switches

CIRCLE 33 ON READER-SERVICE CARD

Computers to Control California Generating Units

LOS ANGELES—

Southern California Edison will put two computer-controlled steam turbine generating units on line at its Huntington Beach Station in 1960. The utility has purchased two General Electric 312 general purpose digital computer systems (CtE, April '59, p. 44), one each for generating units number three and four. On each unit, the computer will direct hot and cold start up, normal and emergency shutdown, and continuous control of the boiler-turbine-generator systems.

• **Accident prevention**—Main reason for the computer control, say utility executives, is to prevent serious accidents that might damage the generating unit. Each of the new units is rated at 210-mw. A serious startup or shutdown accident on a unit that big might cost the utility as much as $1,500,000 to $2,000,000. Experience has shown that most such accidents are caused by human oversights: failure to open or shut a key valve, incorrect sequence of operations, or improper performance of procedure. By restricting the role of the human operator, the computer will assure that the station is started up and shut down with the proper procedure, will not forget to open or close any regulators.

In addition, the automatic supervisory control should reduce the number of unit outages during normal operation by constant scanning of key variables and reporting prompt corrective action during an emergency. In case of unavoidable outages, the computer will get the unit back in service faster.

• **Scanner and logger, too**—On line, the GE 312 system will continuously scan 900 points covering fuel (the plant uses only gas or oil fuel) and water flow, steam temperatures and pressures, and electrical values. It will log 50 critical quantities each hour. Approximately 300 alarm points will also be identified and printed out. Maximum scanning rate of the system will be 300 points per sec.

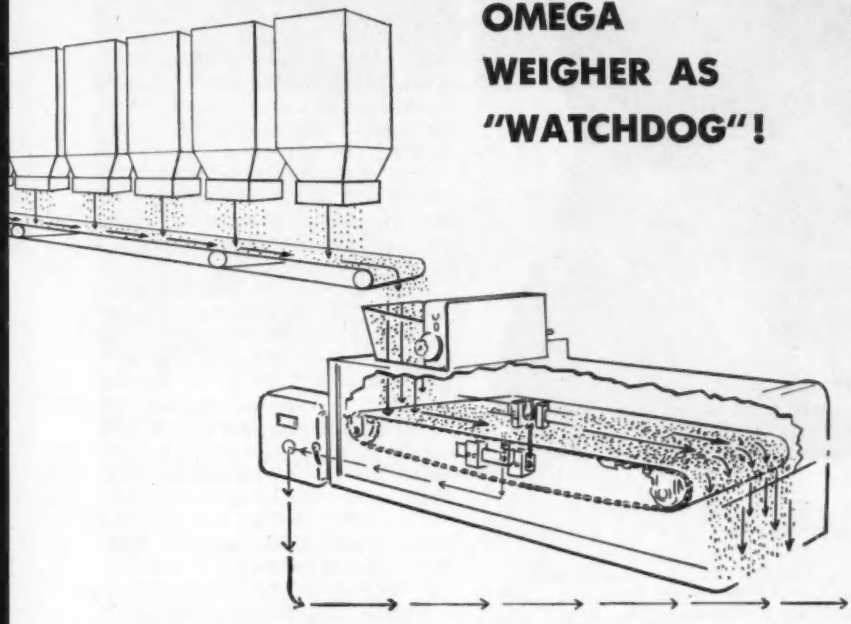
The Southern Cal Edison plant is the second announcement of computer-controlled startup in recent months. In April, Louisiana Power and Light bought a Daystrom Information System for the same purpose at its Little Gypsy Station.

POSITIVE CONTROL OF MATERIALS IN MOTION
METERS FEEDERS CONTROLS

B-I-F INDUSTRIES
BUILDERS-PROVIDENCE • PROPORTIONEERS • OMEGA

PROCESS CONTROL SYSTEMS NEWS

MAJOR FORMULATOR USES OMEGA WEIGHER AS "WATCHDOG"!



OMEGA PNEU-WEIGH SOLVES MANY PROCESS MEASUREMENT AND CONTROL PROBLEMS!

- ★ Checking in-plant inventory
- ★ Weighing incoming and outgoing bulk shipments
- ★ Evaluating process efficiency
- ★ Density checking
- ★ Batch weighing
- ★ Signal producing for pacing additive materials proportional to a variable flow

Process control systems requiring accurate measurement and control of dry materials benefit most from the application versatility of the Omega Pneu-Weigh.

In operation, a suspension scale lever system transfers the weight of the material to a stacked diaphragm pneumatic sensing element. This produces a 3 to 15 psi output air pressure signal representing zero to maximum weighing rate. This signal then operates a pressure gage to indicate *rate* of flow and an integrator to show the *amount* weighed. The pressure signal can be used to operate a chart *recorder,* or to control feeders or other devices.

OMEGA PNEU-WEIGH BELT WEIGHER CHECKS PRODUCTION LINE OUTPUT OF 50 VOLUMETRIC FEEDERS TO MAINTAIN CRITICAL LIMITS... REDUCING PLANT DOWNTIME, LOST MAN HOURS, AND PRODUCTION HOLDUPS!

The proportioning system of a major formulator consists of a line of some 50 volumetric feeders. Each of these feeders puts out its particular fraction of a formula on a continuous basis. Any *one* feeder, departing from its preset output rate, thus upsets the ultimate formulation. If not discovered immediately, the consequences could be embarrassing, costly, or both!

At this particular installation, an Omega Pneu-Weigh 36-20W belt (stream) weigher had been installed at the end of the collector conveyor to "watchdog" the operation through a remote Totalizer-Indicator-Recorder located just outside the manager's office. It immediately became a popular addition to the plant by monitoring production, shut-downs and inventory . . . but *its real value* showed up one day at the start of a long formulation run.

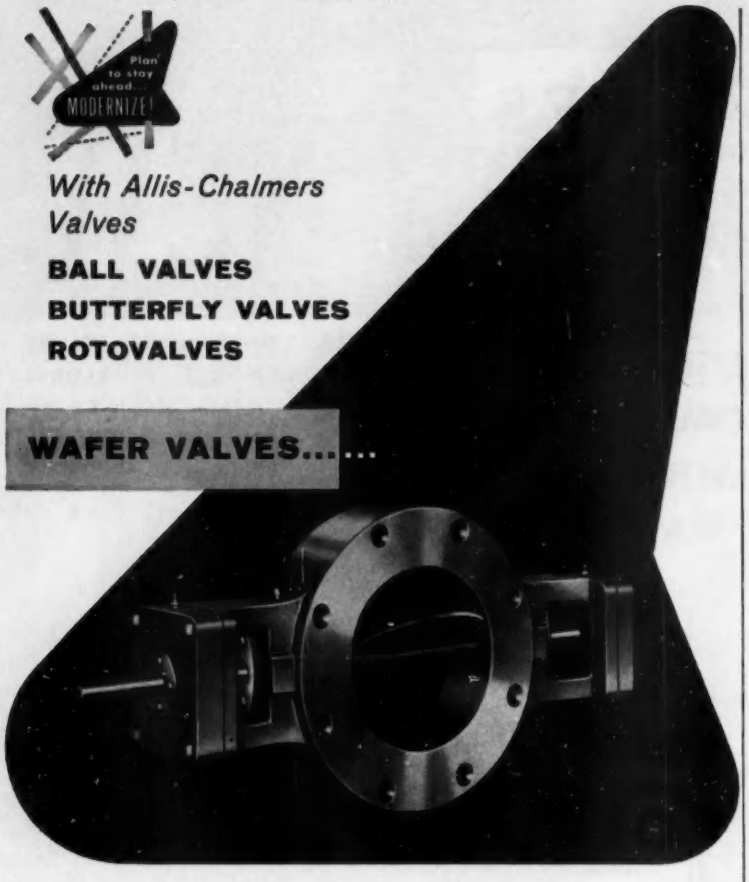
The Pneu-Weigh showed output far less than expected. The line was shut down . . . a hasty check showed the delivery rate of one volumetric feeder was substantially lower than its critical limit. This was quickly corrected and production resumed. If this discrepancy had not been caught at once, over 100 tons of formulated product would have had to be remade at considerable expense in plant time, man-hours, planning, removal of the paper-bag package, and subsequent resacking. The "watchdog", installed on a trial basis, had proved its worth and was purchased shortly thereafter.

CIRCLE 34 ON READER-SERVICE CARD

Omega Pneu-Weigh is a small, compact unit which comes completely equipped . . . ready to operate as soon as connected to air pressure and electricity. It offers *high accuracy* . . . within ± ½% of maximum rate; *wide range,* 10:1 with constant speed drive or 50:1 with variable speed drive; and with maximums from 10 to 3000 lb. per minute. The Omega pneumatic totalizer assures highest accuracy as weight of materials is *continuously integrated* with belt speed.

Accessory equipment includes remote or local totalizer-indicator-recorder which reads directly in *desired* weight unit or per cent of maximum scale; a ratio adjustment unit for tape or card printer; a remote manual gate positioner for volume checking; and hoppers, bin-gates, batch counters and contactors.

Versatile but uncomplicated, no technical training is required for the operation and maintenance of the Model 36-20W Pneu-Weigh Weigher. For complete data on this or other process control systems, write **B-I-F Industries, Inc., Industrial Sales, 528 Harris Avenue, Providence 1, Rhode Island.**



Here's a new wafer valve—with Allis-Chalmers full-bodied design—that incorporates many of the highly-desirable features of two-flanged butterfly valves.

Rugged Construction—A-C full-bodied design affords full protection; there is no chance of cracking around bolt holes. Vanes are pinned to stainless or monel shafts with high-tensile pins. Oversized outboard roller bearings and retaining plates are used. Rugged standard mounting brackets provide maximum support for any operator in any position.

Flexibility—Valves can be provided in a wide variety of alloys to handle all types of fluids and semi-solids over a wide temperature and pressure range. They may be equipped with almost any operator, which may be mounted in several positions on standard A-C bracket assemblies.

Through Rubber Seats—Full rubber seats on A-C Wafer Valves afford maximum body protection and positive, bubble-tight shutoff. Standard seats are of natural gum rubber, neoprene or hycar. Other materials are available on request.

Size Range—Full-bodied A-C Wafer Valves are available in standard sizes from 3 to 36 inches in both 125# and 150# A.S.A. series, rated as shutoff pressure of 50# and 125#.

For information on the complete line of Rotovalves, and butterfly, ball and wafer valves, contact your nearest A-C valve representative, or write Allis-Chalmers, Hydraulic Division, York, Penna.

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A-C ALLIS-CHALMERS

CIRCLE 35 ON READER-SERVICE CARD

EUROPEAN REPORT

Computers in Process Control

An English symposium hears a variety of ways to use computers—both analog and digital—in process control. The reluctant conclusion: theory far outstrips application.

LONDON—

At London's Central Hall, members of three British societies convened last month for a serious symposium on Instrumentation and Computation in Process Development and Plant Design. After listening to three days of presentations in such areas as process control systems, on-line computer applications, analog computer usage, and methods of improving process efficiency, the audience reluctantly concluded that theory far outstrips applications. But even so, the 20 papers supplied the 500 delegates with a variety of new ideas.

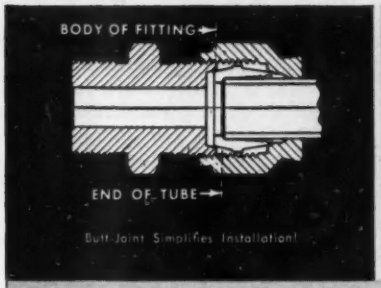
For example, the listeners heard some useful revelations on current methods for distillation column synthesis. Two British engineers, British Petroleum Ltd's J. M. Keating and D. S. Townsend, described how to use a digital computer to determine steady state parameters of a 9,000 barrel per day iso-pentane superfractionator column. Using the data from the computer, the two men plotted a set of graphs which show the steady state relations between the independent variables and product quality.

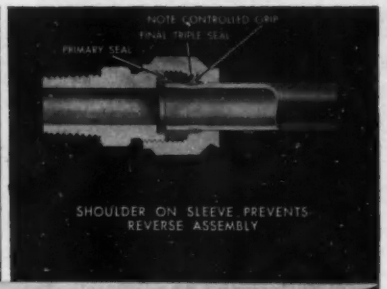
• **Using the Bonner program**—In one case, the percentage pentane in the distillate was plotted against the iso-pentane recovery curves for a family of yield and reflux ratio conditions. Other curves showed the same parameters against reboiler load. By computing on an IBM 650 machine Bonner's plate-to-plate program (which relies on a series of mass and heat balance equations). Keating and Townsend determined the reaction of the dependent variables—distillate purity, reboiler load and iso-pentane recover—for each of four variables of feed temperature, composition, yield. and reflux ratio. C. J. Lvon of the U.K. Atomic Energy Authority described a similar approach applied to exchange processes in deuterium production.

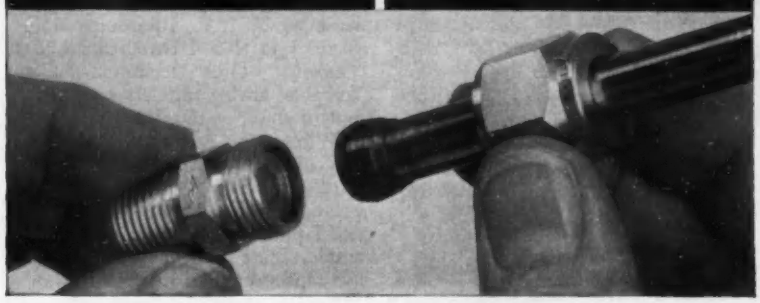
• **Rosenbrock's stepwise solution**—Working with a different philosophy, Dr. H. H. Rosenbrock (Constructors John Brown Ltd) developed a successful analysis of a 300-plate column for heavy water production. Basis of Rosenbrock's approach was the digital solution of the tower differential equa-

IMPERIAL *Engineering and Data File*

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS



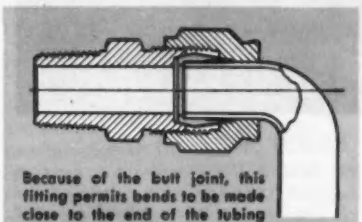




How Hi-Seal tube fitting design simplifies instrumentation piping layouts

The butt-joint feature of Hi-Seal fittings is a design consideration acclaimed by fitting users throughout industry. The tube *does not* enter body of fitting! It bottoms on the shoulder of the sleeve. This butt joint feature makes possible far more compact piping layouts than other fittings.

Users have obtained these benefits: (1) cuts space requirements up to 50%; (2) reduces number of bends required; (3) cuts man hours and installation time; (4) substantially reduces the amount of tubing needed; (5) permits the use of straight lengths of .028″ copper tubing in bending temper instead of .032″ soft tubing in coils; (6) ends need for straightening.



Because of the butt joint, this fitting permits bends to be made close to the end of the tubing where space is limited.

FOOLPROOF ASSEMBLY — Anyone can make leakproof connections with Hi-Seal fittings. There is only one way to assemble the Hi-Seal fitting . . . only one way tubing can go into sleeve . . . only one way sleeve can go into fitting.

Hi-Seal design also makes maintenance of equipment easier through quicker disassembly and assembly of joints — may be disconnected and reconnected as often as desired.

COMPLETE LINE — Hi-Seal fittings are available in brass, steel, stainless steel. Also can be furnished in Titanium, Tantalum and other metals. Steel fittings supplied with cadmium plate or black phosphate finish. Conform to J.I.C., A.S.M.E. and A.S.A. standards. In sizes for ⅛″ to 1½″ O.D. tubing. Furnished with Long Dryseal pipe threads or straight thread port seal.

Write for Bulletin No. 3061

New high-pressure valves assemble directly to tubing, eliminate additional fittings

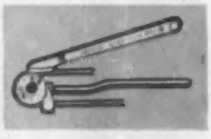
A revolutionary new line of Imperial needle valves designed for working pressures up to 5,000 psi., and temperatures to 450° F., employs Hi-Seal tubing connections.

These valves attach directly to tubing and eliminate additional fittings. This not only reduces cost but cuts installation time and eliminates principal source of leakage.

For low pressure instrumentation service, Imperial also supplies a complete line of fluid control valves in diaphragm, plug, (2, 3, and 4-way styles) — needle and toggle types.

Write for Bulletin 3096, or Catalog No. 200

Dimensional Bends easily made with Imperial Blue Dot Benders



It's no trick to make bends at any desired point — that conform to dimensional requirements as to developed tube length and location — when you use Imperial Blue Dot Benders. Full instructions with each bender.

Imperial Benders are of the open side type. They slip over the tubing where the bend is desired — handy in hard-to-get-at places or when tubing has one end connected.

They form neat, accurate bends on hard or soft tubing without annealing. Calibrated for bending any angle up to 180°.

Wide range of individual and combination benders for 2 to 7 sizes — from ⅛″ to ⅞″ O.D. (⅛″ to ¾″ nom.).

Write for Bulletin No. 3088

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Please rush me: Bulletins ☐ No. 3061 ☐ No. 3096 ☐ No. 3088 ☐ Cat. No. 200

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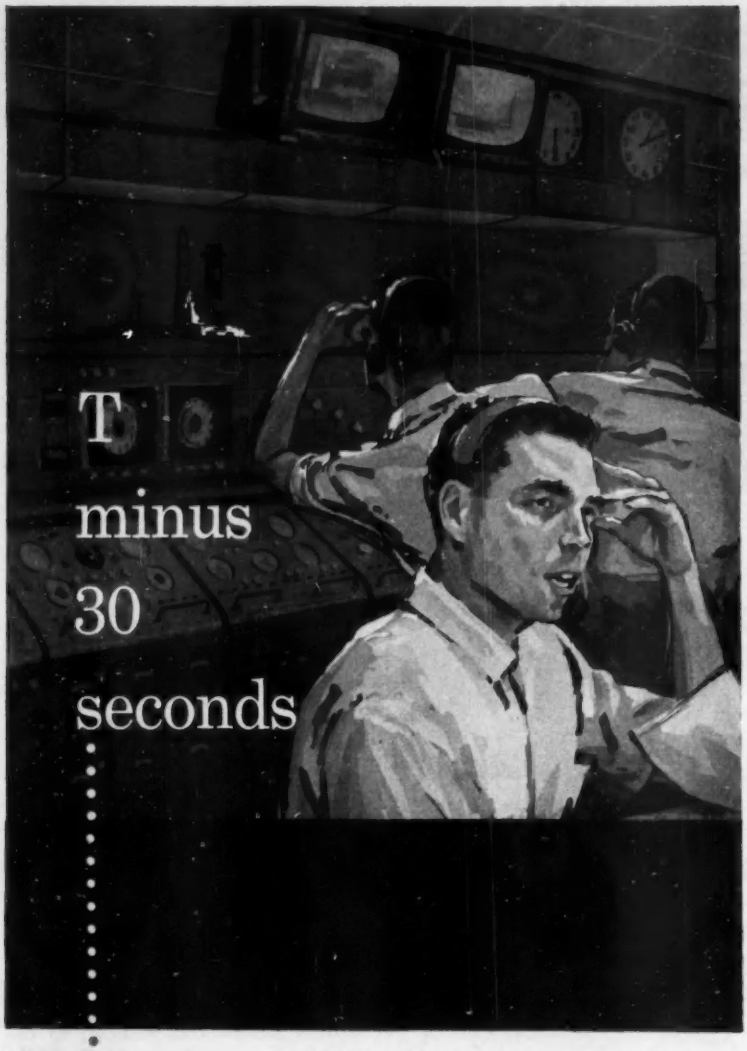

Shown here:
portion of Arnoux-built
telemetry-receiving station.

No technical hold ever resulted because of an Arnoux Telemetering Decommutation System (TDS)...none has ever been returned for factory attention. Routine, minimal field-support calls have kept each unit functioning efficiently and accurately. Engineers prefer the TDS because it's actually possible to "adjust-in reliability."

* The Arnoux TDS accepts all PAM & PDM IRIG inputs... is modular, compact, small... built-in calibration... any channel easily replaced with standby plug-in units... independent linearity within ±½% of full scale... long-term level drift within ±½%... no errors due to SCO center-frequency drift or discriminator dc output-level drift or tape-playback speed variations... no heating problems... simple, novel circuitry. BULLETIN 800b.

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PHONETICALLY, SAY ARE'NEW
DECOMMUTATORS

CIRCLE 37 ON READER-SERVICE CARD

WHAT'S NEW

tions stepwise in time to obtain equilibrium conditions.

Once equilibrium was established, disturbances were introduced into the computer program to determine the variation of each plate when reaching a new equilibrium position. From these plate-by-plate examinations are chosen the most appropriate measuring points and their transfer functions calculated. Analog simulation of the transfer function and the proposed control system then produce the overall system performance.

• **Dynamic behavior simulation**—A major innovation in distillation synthesis was the dynamic behavior simulation based on Voetter's theory announced by J. E. Rijnsdorp and A. Maarleveld (Royal Dutch Shell, Amsterdam). Their technique allows complete analog simulation of a multiplate tower without excessive gear.

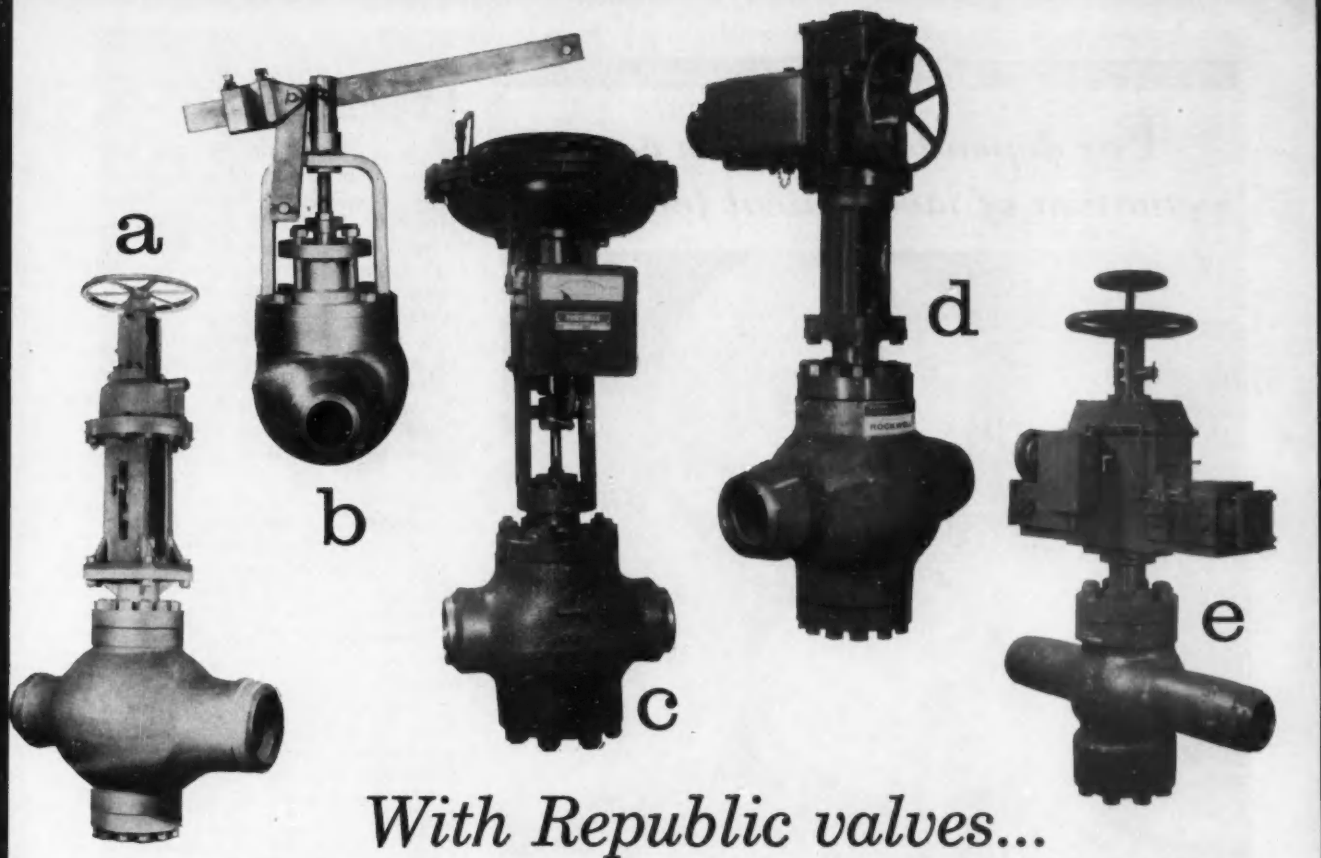
When simulating a theoretical 32-tray atmospheric column, the simulator comprises four basic analogs—pressure, vapor flow, concentration and liquid flow. Only 25 operational amplifiers are needed; six resistors and five capacitors simulate each tray.

Results showed pressure and concentration changes for variations in heating and reflux ratio. The two Dutch engineers were also able to see the interaction effect between the column temperature and pressure control systems when temperature is controlled from reboiler heating and pressure from the condenser cooling medium. The simulation revealed a surprising double resonance effect reducing the column controllability.

• **Optimizing schemes** – Optimization is very much on the minds of British control engineers, and the program mirrowed this interest. E. Shapiro (IBM Research Labs, N. Y.) outlined a theoretical optimizing program for a process computer control system. Then G. A. Coutie, Imperial Chemical Industries, Ltd, presented a highly practical evolutionary operation for optimization.

Over the past five years the operation, already applied to over 40 ICI processes, has upped process yield as much as ten percent. Basis of the approach: small systematic nudgings of the process variables made on a carefully planned and continuously repeated cycle. Modifications are too small to be detected in individual cycles but averaged results over successive cycles provide trend contours.

• **Hardware discussion**—Other sessions of this meeting covered hardware application, revealing Britain's slow start in on-line computer instal-



With Republic valves...

You get longer life, less maintenance

For over 35 years Republic valve developments have paced the changing demands for more sturdy valves by the most progressive utilities and industries. For such services as pump recirculation control, feedwater regulation, steam pressure reducing and high pressure water control, Republic valves have established a reputation for durability, long life and trouble-free performance.

Superior valve design—Republic research into the causes of valve noise and vibration, and also the wear resisting and galling properties of materials has resulted in a modern line of Republic valves of advanced design. Republic valve contours are designed to produce not only the desired regulating characteristics but also to reduce erosion damage and noise as well. Extra large guide bushings, extra deep stuffing boxes, solid plug inner valve construction, plus precise manufacture and long-life materials make Republic regulating valves perform better, last longer, with less maintenance.

Wide selection of valves and features—Rockwell-built Republic regulating valves shown on this page are representative of the complete Republic line:

a. **Cylinder operated valve**
b. **Lever operated valve**
c. **Diaphragm operated valve**
d. **Motor operated valve**
e. **Toggle head operated valve**
f. **Diaphragm operated angle valve**

And, for many special applications, such Republic accessories as pneumatic and electric valve positioners for hysteresis-free control, and a complete line of controllers are available.

Whatever your regulating valve problem, let Republic engineers put their years of application experience to work for you. For additional information, see your Republic representative, or write to Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, Illinois.

REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
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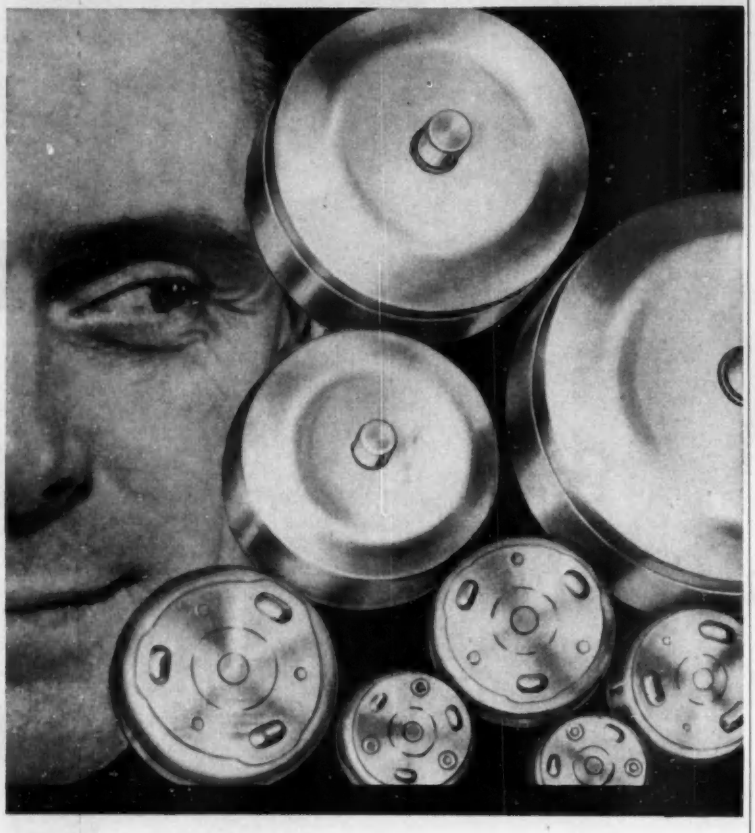
CIRCLE 38 ON READER-SERVICE CARD

For dependable remote control actuation of mechanical loads



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eight compact sizes are available
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ratio of torque to size and weight is extremely high
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CIRCLE 39 ON READER-SERVICE CARD

WHATS NEW

lations. H. H. Idzerda was one speaker who blamed the imitation of other techniques for the lack of real progress. He claimed that electronic system designers made electronic equipment mimic the operation of other techniques instead of taking advantage of its unique potentialities.

As an example of what can be done, he described the electronic flow ratio controller developed at the Amsterdam laboratories of Royal Dutch Shell. The system permits in-line blending accurate to better than 0.1 percent. Price, of the unit will be less than a conventional mechanical blender.

• **Automatic plant**—A combined digital-analog system, described by M. N. Sage, is used in a fully automatic ICI plastics plant. The requirements: speed control of multiple shafts to better than 0.25 percent over a speed range of 5:1, then programmed changes were to be fed in and α or β ray gages would initiate speed changes based on product thickness.

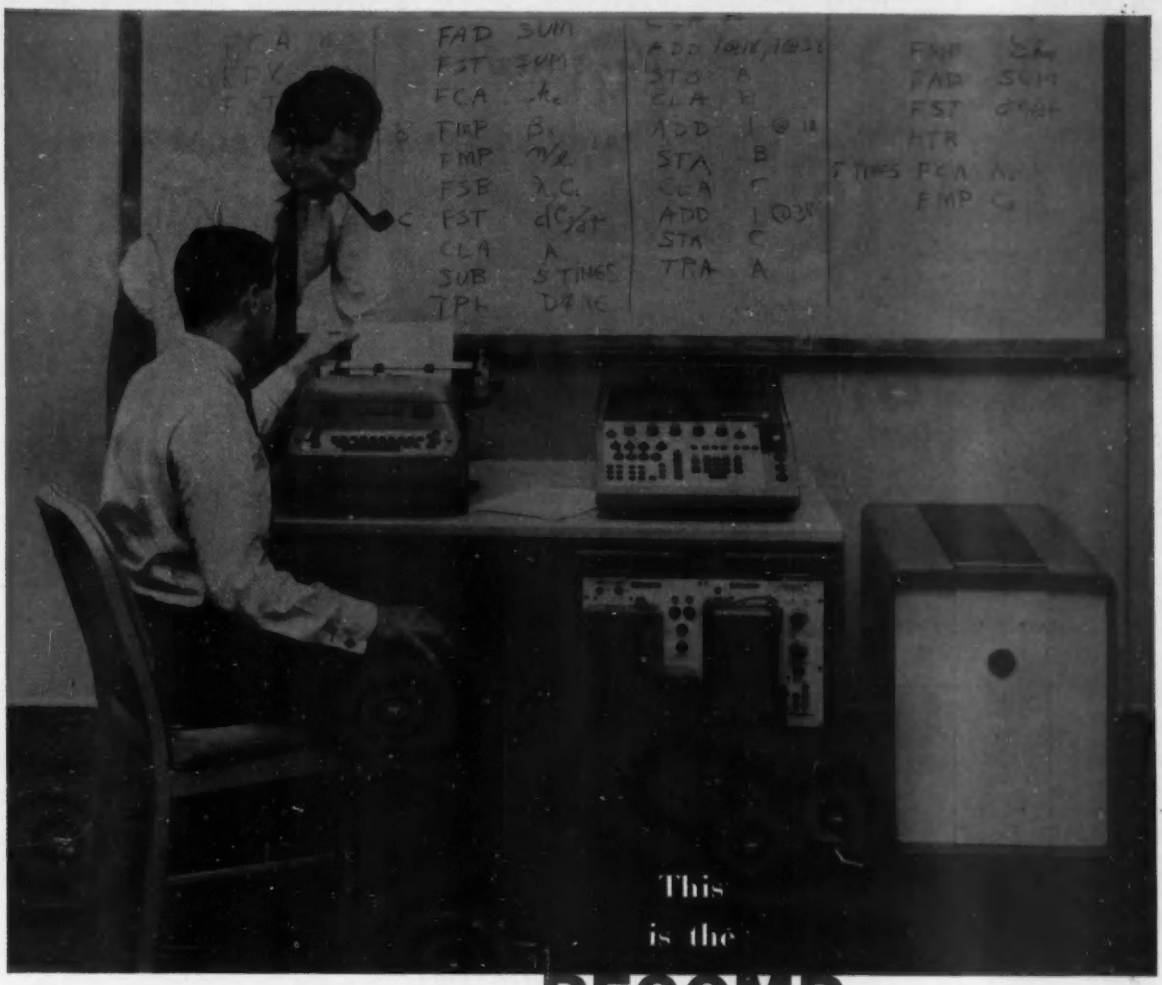
In the two loop servo system, normal analog controllers regulate direct motor speed control on each of four shaft setpoints, controlled from a transistorized timeshared digital computer through a digital servo. Response time for a 15 percent speed change is reduced to less than one minute by linear prediction on the digital servo.

• **From Russia**—A speaker from Russia had some state of the art information to pass along. He reported that special analog computers applied to the study of multi-stand cold rolling problems went into service late in 1958. Divided into three sections, each simulating one stand, the computer had ten integrating amplifiers and 20 summing amplifiers, used nonlinear thyrites for multiplication and for generation of non-linear functions.

Using equations developed by the Central Research Institute of Engineering Technology, Moscow, the Russians were able to simulate both the mill drive control system and the mechanics of the metal reduction through the mill. CRIET claims these equations cover interstand relations.

At the Moscow Computing Research Center optimizing computers for process applications are under development, the symposium heard. First laboratory model is the MH-II analog machine with automatic solution scanning. Simulated in the MH-II are sets of 9th order non-linear differential equations with up to five multiplication terms, 3-6 non-linear relations and 10-12 summations.

—Derek Barlow



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It has a storage capacity of 8,000 instructions ... and it's low-priced

No problem is too complex to tackle with Recomp—and you can afford to put it wherever it's needed to break up computer-time bottlenecks. It's easy to use, too; engineers quickly learn to program their own problems. *Other Recomp features:* a command structure of 49 arithmetical and logical commands—including 9 built-in floating point commands ... standardized teletype tape configuration ... all-transistorized ... 400-character-a-second input ... electronic console that puts all basic controls within fingertip reach ... simplified coding. Recomp gives you far more capacity, versatility, and trouble-free service for your money. It's available for sale or lease. *There's no extra equipment to buy ... no cost of installation.* Please write for complete literature. Industrial Products Division, Autonetics, Dept. 37 3584 Wilshire Boulevard, Los Angeles 5, California.

This engineer learned to program Recomp in two days

Digital computers by Autonetics

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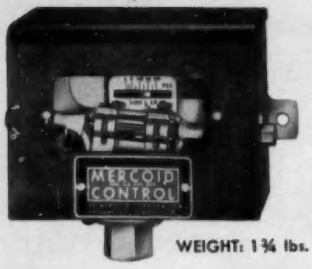
NEW

Small, Lightweight

MERCOID PRESSURE CONTROL

AP-153



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CIRCUIT

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Provides any of following operations:

1. *Single Pole—Cut-in high (close on rise)*
2. *Single Pole—Cut-in low (open on rise)*
3. *Single Pole—Double Throw*

OPERATING RANGE

Adjustable Operating Range	Differential Fixed (Factory Set)	Maximum Surge Limits
1 to 20 psig	0.5 psig.	30 psig.

CONSTRUCTION

ADJUSTMENT: External
PRESSURE ELEMENT: Fairprene diaphragm
PRESSURE CONNECTION: ¼" I.P.S.
MOUNTING: Has two mounting ears (one on each side of control) or control may be pipe mounted by means of the ¼" I.P.S. bottom connection.
INTERNAL WIRING CONNECTIONS: 3 post terminal block.
CASE: NEMA 1—Heavy gauge steel, cadmium plated. Steel cover (with glass front) finished in charcoal-gray.

WRITE FOR BULLETIN 02

THE MERCOID CORPORATION
4201 Belmont Ave., Chicago 41, Ill.

CIRCLE 41 ON READER-SERVICE CARD

AROUND THE BUSINESS LOOP

A Boom? Maybe . . .

. . . but there's no denying the new jauntiness in the economy. And the control field contributes its share, as first-quarter reports show.

By nature a disagreeing race, economists have been known to come together on developments that are sufficiently clear-cut and incontrovertible. Such a development seems to be the current upswing in business. Economists agree: business is good!

In April, the McGraw-Hill Dept. of Economics issued its annual survey of business' plans (CtE, June, p. 46), which indicated, in the department's own words, "a developing business boom". By the middle of May, the very savvy First National Bank of Chicago, in its monthly bulletin, was predicting that inventory buying would persist, plant and equipment spending would be higher than estimated, as corporate profits continued to rise. And very soon afterwards, the U. S. Dept. of Commerce confirmed this prediction, pointed to a record annual rate of $467 billion in national output of goods and services.

But official proclamations that skies are now sunny could hardly be news to those industries whose first-fiscal-quarter reports have, for the past few months, been advising of a change for the better in the business atmosphere. One of these industries is, of course, control. Last month (CtE, June, p. 77), a few user statements were reproduced to show the new trend in the control economy; here, now, are some statements from control makers:

	$	%
Amphenol-Borg	582,108	37.7
	12,980,053	24.5
CEC	340,490	(a)
	10,238,000	45.1
Fairchild Camera	385,000	(b)
	9,735,000	35.0
General Controls	461,759	114.8
	9,675,745	25.6
Hoffman	526,273	20.9
	11,432,477	14.7
IRC	571,204	(c)
	5,489,439	64.4
Standard Coil Products	390,397	(d)
	16,591,852	30.6

Net income loss in first-quarter 1958 of: (a) $274,220, (b) $209,000, (c) $150,287, and (d) $266,508.

These were picked at random. The first figure is net earnings, the second net sales; percentages reflect increases over the first quarter of 1958.

The statements speak for themselves, but perhaps one thing should be especially noted. Of the seven random statements, four show net income losses in the first three months of 1958, but remarkably healthy recoveries in the comparable period of 1959. They are powerful testimony to the resiliency and strength of the young, vital control field.

Incidentally, the Commerce Dept., the last of the three economic groups to signify its findings, pointed to increases in nearly every sector of demand except exports. That included consumer and business purchases, home construction, government purchases of goods and services, and industrial inventories.

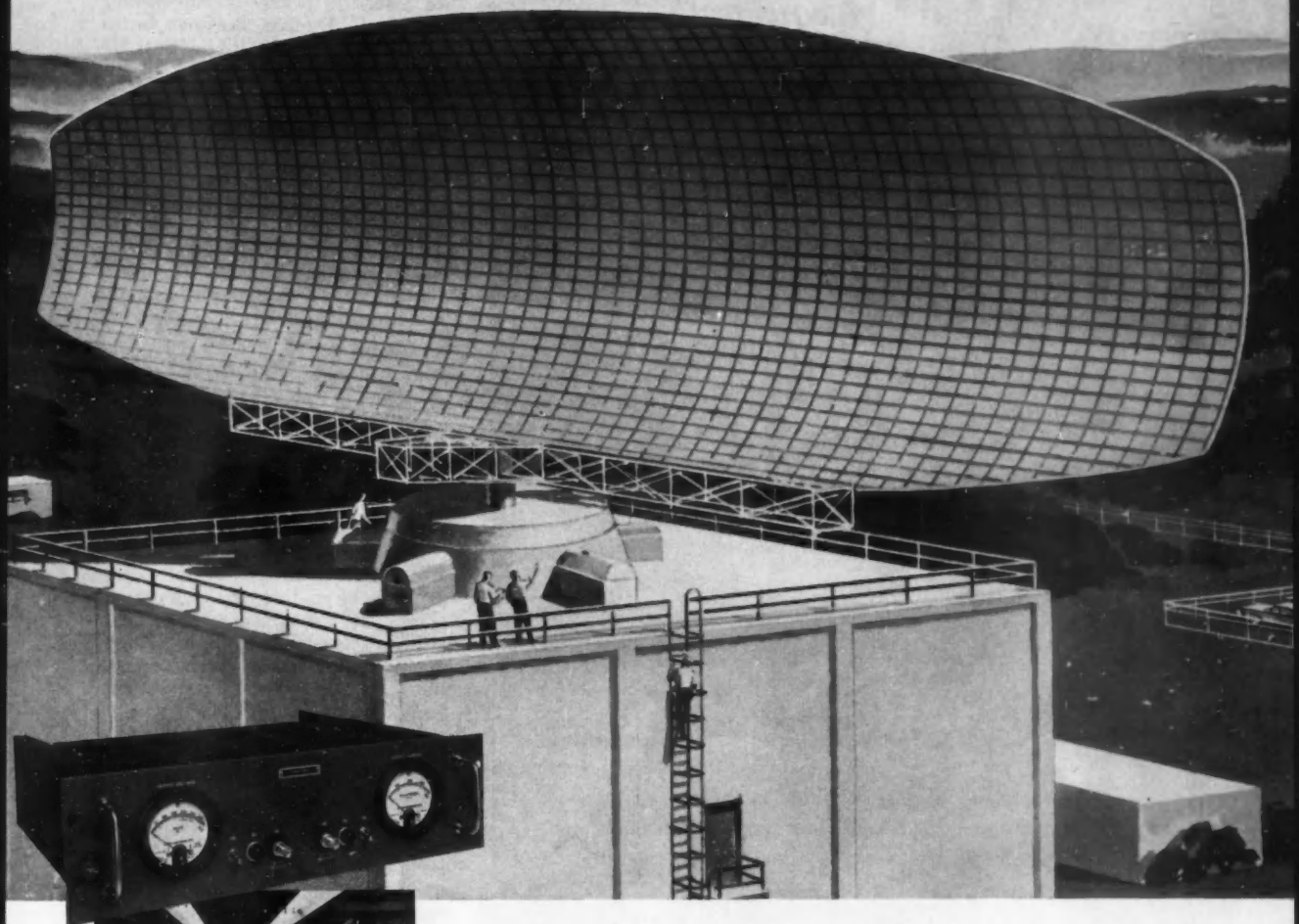
First SBI Firm Is Control-Oriented

Last April, in San Diego, Calif., Electronics Capital Corp. filed an SEC statement covering a proposed offering of 1,200,000 shares of common stock. It was seeking a license under the Small Business Investment Act of 1958, the act that embodies the legal machinery for setting up companies that help other companies financially (CtE, Dec. '58, p. 120). When it is operative, ECC will probably be the first firm established under the act.

Significantly, the new firm's target will be small electronics companies, both independent producers and those that band together to set up product development programs or to compete for government and other contracts. Assistance will be of a technical and financial nature, the latter provided by purchase of convertible debentures. ECC will also look out for shareholders of these small firms, will see that they get the various tax benefits due them for their willingness to invest in, and thus encourage, small businesses.

President of ECC is Charles E. Salik, who heads Electronic Investment Corp., a fast-growing mutual fund located in San Diego. The executive vice-president is Richard T. Silberman, formerly vice-president

Lambda Power Supplies specified for newest radar installation



"Off-the-shelf" Lambda power supplies —modified only with special panels, MIL meters and tubes—will be part of the complex radar equipment housed in the 85-foot tower at Thomasville, Alabama, one of four identical installations.

Meet MIL-E 4158 environmental test requirements

Sperry Gyroscope Co., operating under the technical guidance of the Rome (N.Y.) Air Development Center, is producing the new SAGE radar equipment (AN/FPS-35). The power supplies employed to power transmitters and receivers must be able to pass stringent tests.

Sperry's choice: Lambda's COM-PAK®, already widely used as a component in many rocket and missile programs.

All Lambda stock industrial power supplies are made to MIL quality and *guaranteed for five years.* They are pictured and described in a new 32-page catalog. Write for your copy.

LAMBDA ELECTRONICS CORP.

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CIRCLE 42 ON READER-SERVICE CARD

WIANCKO'S NEW 3000*

AM carrier equipment

*

Exceptionally reliable in the past, Wiancko's new 3000 cycle carrier equipment represents a decade of evolutionary refinement. The basic equipment has been the heart of instrumentation systems for many successful rocket engine manufacturers, wind tunnel operators, and missile propellent producers. To meet today's more demanding accuracy and reliability requirements, **these people are equipping their facilities with the new 3000!**

- *convenient electrical calibration*
- *high level signals*
- *modular design*

Advanced component design offers a variety of options for compatibility with both analog and data systems. A minimum of vacuum tubes combined with conservatively rated circuitry, provides the maximum in reliability and utility. For more information on **the new 3000** write for bulletin 109.

Wiancko Engineering Company

255 North Halstead Avenue • Pasadena, California

CIRCLE 43 ON READER-SERVICE CARD

WHAT'S NEW

Electronics and a director of Electronics Investment. Other directors include Neil H. Jacoby, dean of UCLA's Graduate School of Business Administration; Joseph M. Pettit, dean of Stanford's School of Engineering; Donald C. Duncan, Beckman Instruments; and J. J. Rice Jr., the First National Trust & Savings Bank of San Diego.

The new company is offering its common stock at $10 per share.

To be eligible for the kind of assistance ECC is prepared to offer, a small firm must have annual earnings of not more than $150,000 and total assets of not more than $5 million. The Small Business Administration can, of course, change these limits if it sees fit.

GE Gives a New Look to Power Tube Marketing

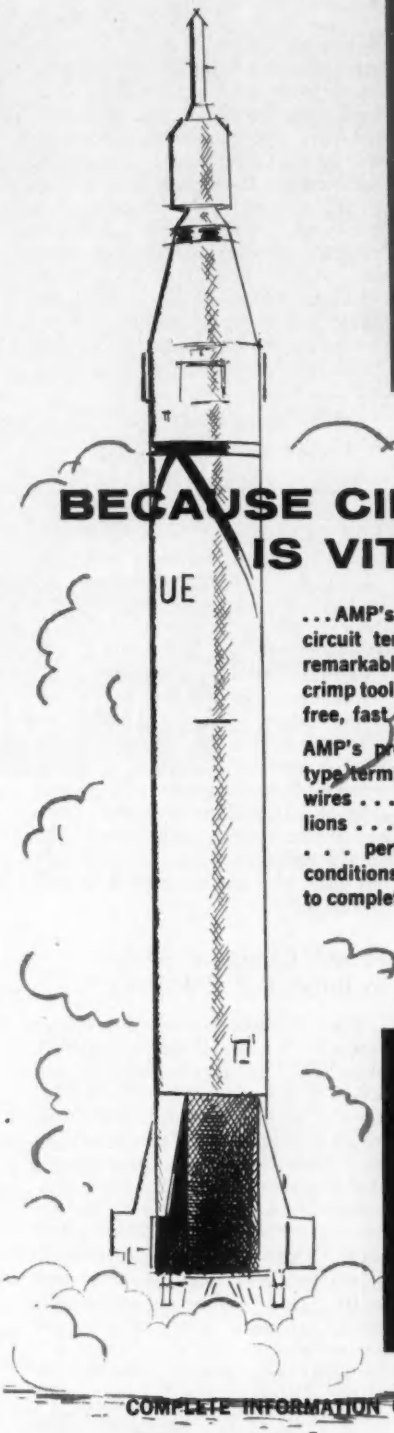
General Electric Co. is continuing to make interesting alterations in its marketing techniques. One of the latest changes involves the Power Tube Development Dept. in Schenectady, N. Y., which has been reorganized on a product-line basis, with three new managers of product sales planning replacing one manager of product planning. Each new manager will be responsible for specific product lines, and will report to Marketing Manager F. L. Miller.

In contrast to the move at Schenectady, which seems to be toward a product-oriented establishment, one affecting the GE Instrument Dept. (CtE, May, p. 50) is definitely market-oriented: several selected product lines are sold to specific markets instead of one line being sold to all markets. Proponents of both techniques claim more effective operation and better customer service.

The new managers at Schenectady are Ardell C. Rowe, who will handle beam tubes; Keith E. Wilson, whose area will be ignitrons, thyratrons, and special-purpose tubes; and Wilbur F. McKeehan, who will concentrate on magnetrons, space charges, and camera tubes. Albert C. Gable, the former manager of product planning, has been named manager of market research and product planning practices.

Swartwout Refinery Contract Believed Biggest of Its Kind

A contract to furnish an all-electronic control system for a new refinery on Bataan Peninsula, Philippine Islands, has been awarded to The



STRATO-THERM

TERMINALS AND SPLICES

- up to 1200°F. operating temperature
- solid, stranded or combination conductors
- shock and corrosion resistant
- wire size range 22-10 AWG
- serrated inner barrel for maximum tensile strength

CERTI-SEAL SPLICES

AMPLI-NYL TERMINALS AND SPLICES

- combined wire size range 22-2/0 AWG
- exceed millivolt-drop specifications
- finest nylon pre-insulation
- shock and corrosion resistant
- color coded by wire size

BECAUSE CIRCUIT RELIABILITY IS VITAL . . .

. . . AMP's product is more than fine circuit terminals . . . more than remarkably precise compression-crimp tooling . . . more than an error free, fast method of attachment.

AMP's product is finished crimp-type terminations on your circuitry wires . . . by the hundreds or millions . . . of the highest reliability . . . performing under gruelling conditions . . . from basic terminals to complete patchcord systems.

PATCHCORD PROGRAMMING UNITS

(Airborne "240" shown)

- universal or shielded systems
- patented wiping action pre-cleans pins and contact springs
- nylon sleeve insulates and firmly seats patchcord pin in board
- contacts have rear board accommodation for taper pins to provide reliable solderless lead terminations

200 CONTACT CABLE CONNECTORS

- extremely reliable disconnect for ground electronic and instrumentation application
- connector can be electrically disengaged without mechanical separation
- five indexed positions to permit strain-free cable exit
- identical inserts and contacts in both halves
- polarized to prevent improper coupling—has numbered cavities to assure proper circuit identification

COMPLETE INFORMATION ON THESE FOUR PRODUCT LINES IS AVAILABLE ON REQUEST.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Japan

CIRCLE 44 ON READER-SERVICE CARD

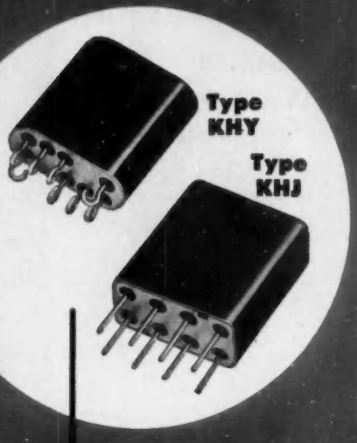
ALLIED'S NEW ADDITIONS TO THE
KH SUBMINIATURE LINE

Types KHJ and KHY
GENERAL FEATURES:
Contact Rating
Contact Arrangement—DPDT
Contact Rating—
low-level up to 2 amps at 29 volts d-c,
1 amp at 115 volts a-c 400 cps
non-inductive or 0.5 amp inductive.
Life—100,000 minimum at 125°C
Also available 3 amps at 29 volts d-c
2 amps at 115 volts a-c 400 cps
non-inductive or 1 amp inductive.
Life—100,000 at 3 amps or 500,000
minimum at 2 amps at 125°C
Initial Contact
Resistance—0.05 ohms maximum
Contact Drop—1 millivolt maximum
at low level rating, initial and during
low level mike test.
Operate Data:
D-C Coil Resistance—up to 10,000 ohms
Nominal Power—1.2 watts
Pull-in Power—240 milliwatts (standard)
100 milliwatts (special)
Operate Time—5 milliseconds max.
Release Time—3 milliseconds max.
Dielectric Strength:
1000 volts rms at sea level
500 volts rms at 70,000 feet
350 volts rms at 80,000 feet
Insulation Resistance:
10,000 megohms minimum at 125°C

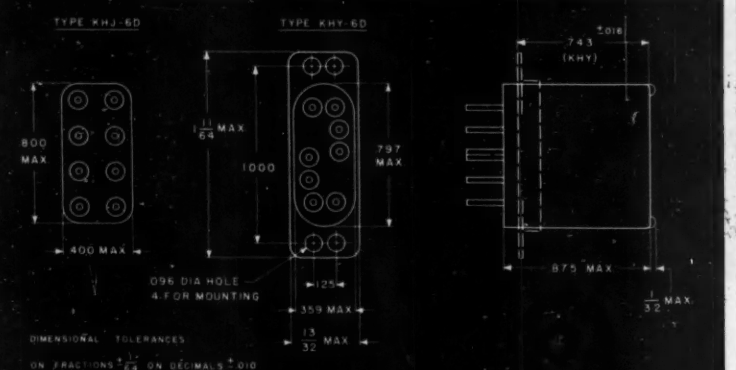
ENVIRONMENTAL FEATURES
Vibration:
5 to 10 cps at 0.5 inch double amplitude
10 to 55 cps at 0.25 inch double amplitude
55 to 2000 cps at 20 g
Shock: 100 g's operational • 200 g's mechanical
Ambient Temperature: —65°C to +125°C

MECHANICAL FEATURES
Weight: 0.5 ounce
Terminals:
Hooked Solder • Plug-in • Printed Circuit
Mountings:
2 or 4 hole brackets at base or center of gravity
1 or 2 studs on top or side of housing

MILITARY SPECIFICATIONS
MIL-R-28518 • MIL-R-5757C



Allied's type KHJ and KHY subminiature relays have a higher contact rating than Allied's original subminiature relay and are designed to meet the increased vibration and shock requirements of the latest MIL specs. In addition, the type KHJ relay has incremental grid spaced terminals for application to "Automation" assembly. Both relays are available with brackets for mounting interchangeable with that of Allied's type KH subminiature relay.



ALLIED CONTROL
ALLIED CONTROL COMPANY, INC., 2 EAST END AVENUE, NEW YORK 21, N. Y.

CIRCLE 45 ON READER-SERVICE CARD

WHAT'S NEW

Swartwout Co. by Standard Vacuum. Estimated at about $250,000, it is believed to be the largest contract of its kind ever assigned by the petroleum industry. Field-mounted instruments will be specially designed to withstand the corrosive atmosphere of the tropics.

Components will include a two-stage crude unit, naphtha desulferizer, catalytic reformer, distillate desulferizer, TCC cracker, TCC fractionator, TCC gas plant, alkylation unit, and steam and power generator.

Swartwout introduced its all-electronic process control in 1951.

Textile Mills Organize A Data-Processing Group

Thirty textile mills have formed a Textile Data Processing Association to pool information about problems, methods, and experiments having to do with the processing of business data by electronic computer and other calculating means. Chairman Harold E. Williams of The American Thread Co., New York, has been steering development of his own firm's data processing center. The new association will meet twice a year, is open to mills in the following classifications: a weaver of broad goods with annual sales of $25 million or more; a yarn and thread spinner with annual sales of $10 million or more; and a finishing plant with annual sales of $5 million or more.

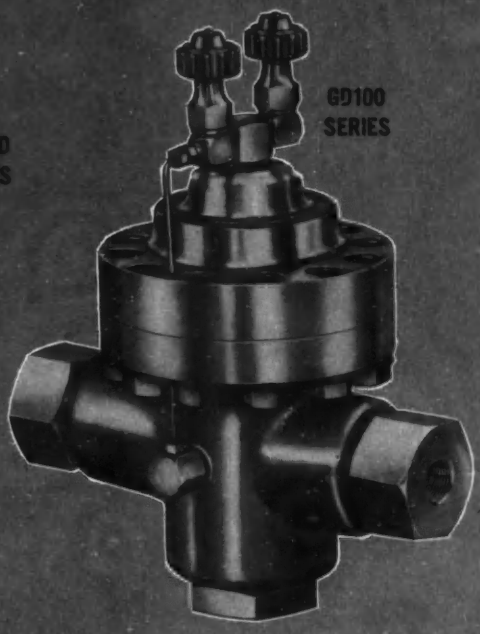
French Computer Maker to Build, Sell RW-300's

The Thompson-Ramo-Wooldridge Products Co. has licensed Intertechnique Co. to manufacture and sell RW-300 computers in France and French possessions. Intertechnique, which is located near Paris, has a contract from the French government's electric power utility to furnish a computing data-logging system for the nation's first commercial nuclear power plant. This will, incidentally, incorporate two RW-300's to detect and locate pinholes, splits, and other faults in fuel cartridges, print out data, and actuate alarms. The French firm is a subsidiary of General Areonautique Marcel Dassault, the largest aircraft company in the country.

Northrop Buys Builder of Communications Networks

Northrop Corp., West Coast electronic weapons builder, has acquired

GD60 AND 80 SERIES



GD100 SERIES

LR20B SERIES

Control gases safely, accurately

TO 15,000 PSI AND 50,000 SCFM WITH VICTOR REGULATORS

You get precise regulation of high pressure gases with large flow rates, because Victor employs gas pressure to control the regulating diaphragm. The result is accurate delivery from 5 to 15,000 psi with inlet pressures to 15,000 psi . . . plus ability to obtain flows in excess of 50,000 scfm at maximum inlet and outlet pressures. Chart below shows operating range of standard models.

MODEL NO.	MAX. INLET PSI	MAX. OUTLET PSI	FEATURES	MAX. FLOW SCFM
GD10	3,600	500	Single adjustment regulator control	250
GD30	2,500	2,500	Load & bleed valve control	400
GD31	3,600	3,600	Load & bleed valve control	600
GD61C	2,500	2,500	Load & bleed valve control	170
GD62C	3,600	3,600	Load & bleed valve control	200
GD65	6,000	6,000	Load & bleed valve control	250
GD65C	7,000	7,000	Load & bleed valve control	250
GD80A	5,000	5,000	Load & bleed valve control	500
GD81A	10,000	10,000	Load & bleed valve control	800
GD86R	10,000	10,000	For remote control only	1,200
GD100R	6,000	6,000	For remote control only	20,000
GD100	6,000	6,000	Load & bleed valve control	20,000
GD200	6,000	6,000	Load & bleed valve control	50,000
GD700	7,000	7,000	Single adjustment regulator control; self relieving	250
SR10	3,600	1,000	Small, spring loaded regulator	4
LR20B	7,000	7,000	Spring loaded regulator; self relieving	2
LR20BSS	10,000	10,000	Spring loaded; stainless steel	2
LV10	7,000	7,000	Loader valve control	15
BPR10	7,000	7,000	Back pressure regulator	2

Operating temperature range: −67°F. to +250°F.

. . . Yours for the asking Take advantage of Victor's long experience with high pressure gas regulation to help solve your special problems involving flow rates, delivery pressures, corrosive fluids and temperature compensation. Write, wire or phone us today. No obligation.

All models listed are field proved. Most are designed for panel mounting or remote control. They regulate all non-corrosive gases, including oxygen. Stainless steel models available for corrosive gases and pressures above 10,000 psi. For complete specifications, write for Victor High Pressure Regulator sheets.

VICTOR® for regulators

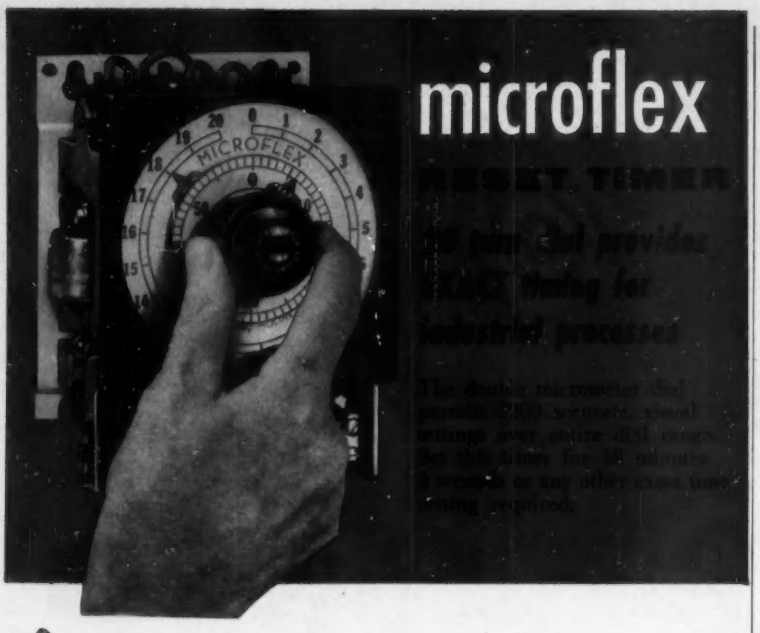
VICTOR EQUIPMENT COMPANY MISSILE DIVISION 57

Mfrs. of High Pressure and Large Volume Gas Regulators; welding & cutting equipment; hardfacing rods; blasting nozzles; cobalt & tungsten castings; straight-line and shape cutting machines.

844 Folsom St., San Francisco 7 • 3821 Santa Fe Avenue, Los Angeles 58 • 1145 E. 76th St., Chicago 19

J. C. Menzies & Co., Wholly-Owned Subsidiary

CIRCLE 46 ON READER-SERVICE CARD



Savings

- Large 15 ampere contacts eliminate additional load relays.
- Stop down time with plug-in components for fast timer replacement.

Flexibility

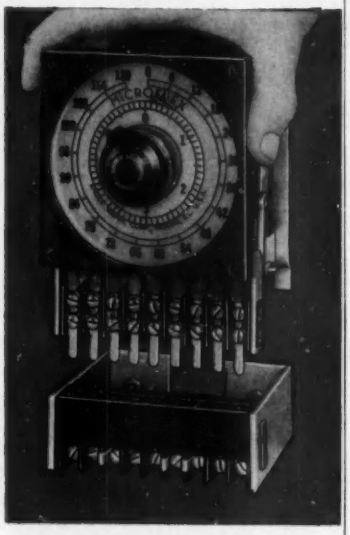
- Easy to set dial whether short or long timing.
- Choice of 9 actions available for each of 3 contacts. Select operation required for your circuit.

Accuracy

- Set dial to exact time required. No guessing at numbers.
- Accurate repeatability insures uniform production.

Reliability

- Proven reliability in thousands of industrial processes for more than 25 years.



Install timer in seconds with optional plug-in feature.

EAGLE SIGNAL COMPANY
A Division of the Gamewell Company
Dept. CE-759
MOLINE, ILLINOIS
Please send FREE Bulletin 110 containing complete data on Microflex Reset Timers.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

CIRCLE 47 ON READER-SERVICE CARD

WHAT'S NEW

Page Communications Engineers, Inc., of Washington, D. C., pioneer in the application of scatter-propagation techniques to intercontinental communications networks. Most of Page's work is for the armed forces; it includes scatter systems connecting the U. S. and Greenland, and the U. S. and England, a multi-channel system in the Pacific for the Signal Corps, projects for the Navy in North Africa, Italy, and Morocco, and siting and path-loss tests for the DEW East project of the Air Force.

Anxious to broaden its scope, Northrop sees in world-wide communications work the best supplement to its efforts in electronics, guided missiles, manned aircraft, target drones, and other weapons systems. It gave Pace 95,000 shares of stock, got all of Pace's in return. The Washington firm will become a Northrop subsidiary.

Other Acquisitions

Pacific Electronic Controls Corp. of Monrovia, Calif. (precision potentiometers) by **Royal Industries, Inc.**, of Los Angeles.

Universal Dynamics Corp. of Santa Barbara, Calif. (piezoelectric ceramics) by **Acoustica Associates, Inc.** (ultrasonic equipment).

IBM Reshuffles Divisions in 'Major Reorganization'

In what it calls a major reorganization, IBM has split its Data Processing Div. into three parts, combined its Military Products Div. and its Washington Federal Office, and set up two new corporate groups to supervise all these new operating arms, as well as some others. Specifically:

• The Data Processing Div. (punched cards and electronic processing systems) has been separated into a marketing division, which retains the name Data Processing Div. and will market and service all punched card accounting machines and electronic data processing systems to all domestic outlets except the government; and a Data Systems Div. and a General Products Div., the first to develop and manufacture large-scale electronic data processing systems and the second to produce small computing systems, and punched card accounting machines.

• The Military Products Div. and the Washington Federal Office have been combined to form a Federal Systems Div., which will engineer and produce special military data-processing systems, and in addition,

"PACKAGING" MICROWAVES FOR MOUNTAIN TOPS

"TJ" radio-relay station at Black Mesa, Arizona

In Arizona, the telephone company faced a problem. How could it supply more telephone service between Phoenix and Flagstaff—through 135 miles of difficult mountain territory?

Radio offered the economical answer: a new microwave radio-relay system recently created at Bell Telephone Laboratories. Operating at 11,000 megacycles, it was just right for the distance, and the number of conversations that had to be carried.

But first other problems had to be solved: how to house the complex electronic equipment; how to assemble and test it at hard-to-reach relay stations way up in the mountains; and how to do it economically.

On-the-spot telephone company engineers had some ideas. They worked them out with engineers at the American Telephone and Telegraph Company and at Bell Telephone Laboratories. The result: a packaged unit.

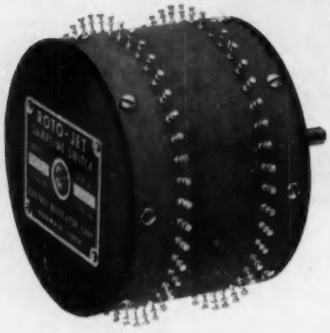
The electronic equipment was assembled in trailer-like containers at convenient locations and thoroughly checked out. The complete units were then trucked up the mountains and lifted into position.

The system, now operating, keeps a watch on itself. When equipment falters, a relay station switches in standby equipment, then calls for help over its own beam.

The new Phoenix-Flagstaff link illustrates again how Bell System engineers work together to improve telephone service. Back of their efforts is the constant development of new communications systems at Bell Telephone Laboratories.

BELL TELEPHONE LABORATORIES *World center of communications research and development*

HIGH SPEED SWITCHING



NEW ROTO-JET®

SEQUENTIAL SAMPLING SWITCH
MAKES MORE THAN 3,600 CLOSURES/SECOND

No commutator to cause noise and wear! Contacts are closed by a **rotating jet of air!** New self-cleaning ROTO-JET represents the most outstanding development in long life, high speed switching in many years.

At low power levels, signals of 1, 2, and 3 millivolts can be directly transmitted free of measurable noise. Flexible, versatile, **module contact** design enable ROTO-JET to be built with any number of contacts required for a specific application.

Here is the long awaited innovation in high speed sampling and switching where a large number of voltage-generating elements must be connected successively to a single load. ROTO-JET is the perfect solution for **directly** commutating signals from thermocouples; strain gages; light-sensitive devices; and similar low level, high impedance elements employed in computers, telemetering systems, and complex process control. For full details, write for new Bulletin No. 8.030.

Just compare!

ANY SAMPLING SPEED—Sampling or switching speeds up to 40 revolutions per second.

SPLIT-SECOND CONTACT—Closing time less than 60 microseconds; opening time less than 80 microseconds.

2-POLE SWITCHING—Easily supplied to any phase angle.

POSITION INSENSITIVE—Mounts in any position; no effect on precision operation or performance.

NO MAINTENANCE—Wiperless contact design. Routine cleaning of contacts accomplished while switch is operating simply by increasing air pressure for several seconds.

ROTO-JET®

ELECTRIC REGULATOR CORPORATION

Norwalk, Connecticut

Manufacturers of REGOHM® Regulators, MAGOHM® Magnetic Amplifiers, and GOVOHM® Diesel Generator Governors.

CIRCLE 48 ON READER-SERVICE CARD

market commercial data processing systems to government agencies.

• A corporate group has been formed, under T. V. Learson, vice-president and group executive, to supervise the new Data Systems Div., the new General Products Div., and an almost-as-new Advanced Systems Development Div., which will design and build commercial machine systems to mechanize specific information-handling areas.

• Another corporate group, under Vice-President McLain B. Smith, will contain the new Data Processing Div., the new Federal Systems Div., the Supplies Div., and the Service Bureau Corp., a subsidiary.

New appointments made in line with the reorganization include:

William B. McWhirter, formerly general manager of the Supplies Div., named general manager of the Data Systems Div., located at Poughkeepsie, N. Y.; Orland M. Scott, formerly manager of Service Bureau Corp., named general manager of the General Products Div. (Endicott, N. Y.; Burlington, Vt.; Rochester, Minn.; and San Jose, Calif.); James E. Swaine Jr., named general manager of the Supplies Div.; and Frank J. Cary, president of Service Bureau Corp.

McLain Smith, who takes over the second executive group, formerly was vice-president and general manager of the old Data Processing Div.

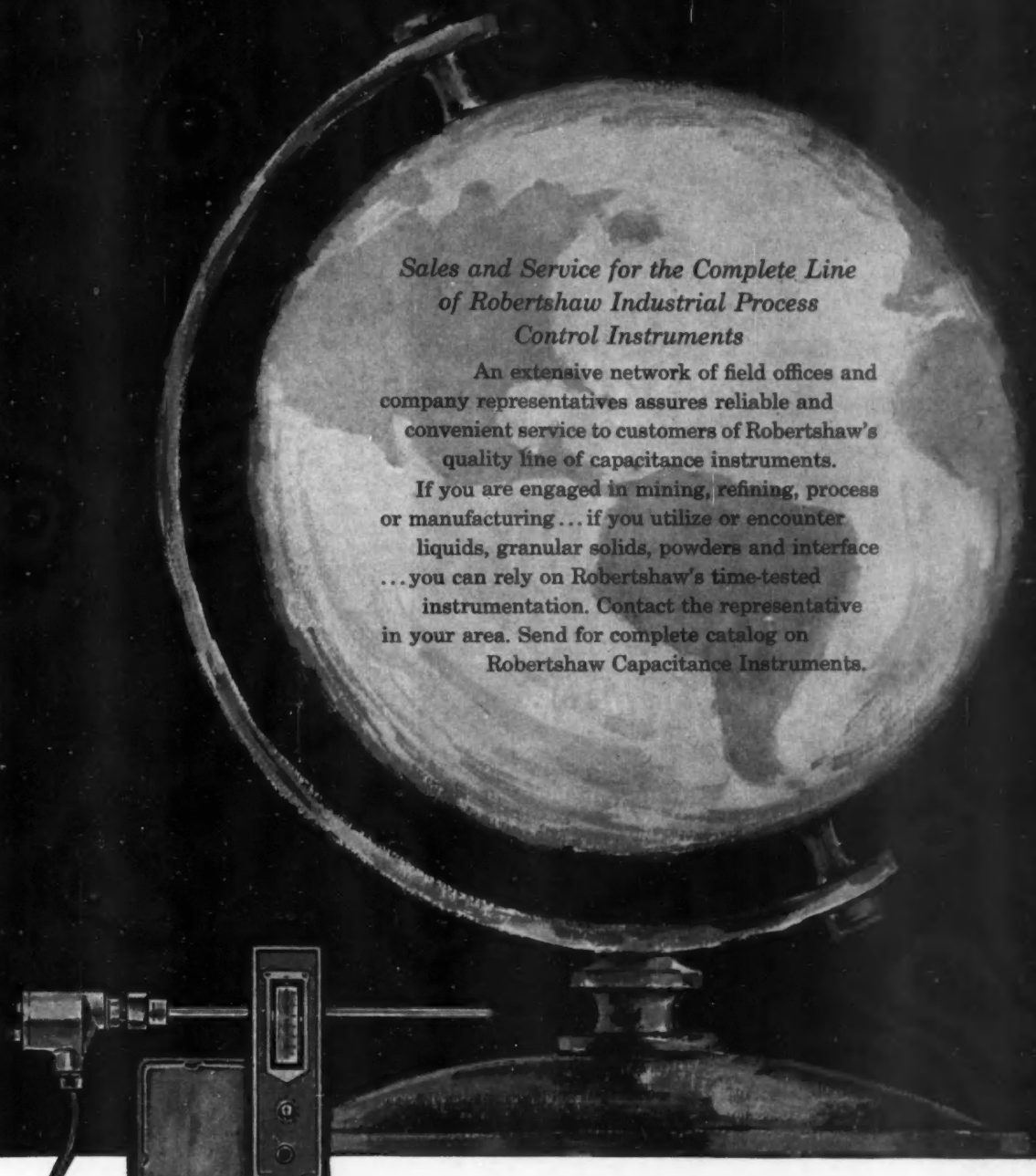
Lockheed Acquires Stavid Engineering

With the exchange of two and a half shares of Lockheed Aircraft stock for every one of Stavid Engineering, Inc., Stavid last May became a Lockheed property. And added its 1,000 employees, mostly specialists in military electronics, to the big Lockheed aircraft-missile machine, to form a complex with a highly respectable ability to compete for a wide chunk of air, space, and industrial systems.

Formed after World War II by David F. Sanders and two other Western Electric engineers, Stavid immediately began growing fast. In the past five years alone, the Plainfield, N. J., company increased its size four times, finished 1958 with sales of $11,277,000. Sanders will remain as president, Frank J. Reynolds as executive vice-president, John H. Hunt as vice-president of manufacturing, and William A. Schneider as vice-president of R&D.

A team of small firms, led by Stavid, successfully competed some time ago

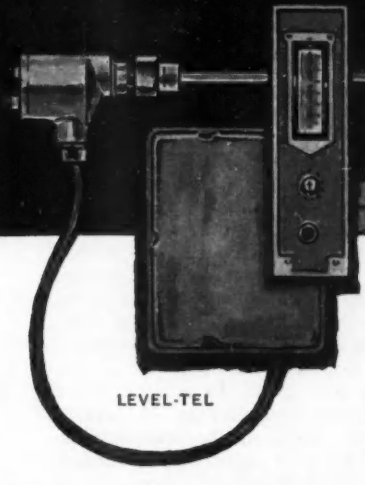
There's a Robertshaw Representative Almost Everywhere



Sales and Service for the Complete Line of Robertshaw Industrial Process Control Instruments

An extensive network of field offices and company representatives assures reliable and convenient service to customers of Robertshaw's quality line of capacitance instruments.

If you are engaged in mining, refining, process or manufacturing... if you utilize or encounter liquids, granular solids, powders and interface ...you can rely on Robertshaw's time-tested instrumentation. Contact the representative in your area. Send for complete catalog on Robertshaw Capacitance Instruments.



LEVEL-TEL

LEVEL-TEL. A continuous level system which detects, measures and visually indicates changes in media level. **LEVEL-TEK.** An on-off device which operates local or remote warning devices or motor driven valves and pumps when a predetermined level is attained. **LEVEL-SET.** An instrument which converts changes in level to proportional changes in air pressure for maintaining a constant head in vessels where pneumatic feed control systems are employed. **LEVEL-LOG.** A versatile and extremely accurate RF null balance capacitance system for level measurement, recording and control. **Robertshaw-Fulton Controls Company, Aeronautical & Instrument Division, Santa Ana Freeway at Euclid Avenue, Anaheim, California.**

CIRCLE 49 ON READER-SERVICE CARD

OFFICES IN THESE PRINCIPAL CITIES – WRITE FOR ADDRESS: Albuquerque N.M – Atlanta, Ga. – Baton Rouge, La. – Billings, Mont. – Birmingham, Ala. – Brookline, Mass. – Charleston, W. Va. – Charlotte, N.C. – Chicago, Ill. – Cincinnati Ohio – Cleveland Ohio – Dallas Texas – Denver, Colo. – Des Moines, Iowa – Detroit, Mich – Edmonton Alberta, CANADA – El Paso, Texas – Houston, Texas – Huntington, N.Y. – Indianapolis, Ind. – Kansas City, Mo. – Kingsport, Tenn. – Louisville, Ky. – Lubbock, Texas – Marion N.C – Memphis Tenn – Mercer Island, Wash – Mexico City, D.F. – Milwaukee, Wis. – Minneapolis, Minn. – Montreal, Quebec, CANADA – New Haven, Conn. – New Orleans La. – North Vancouver B.C., CANADA – Odessa, Texas – Omaha, Neb. – Orinda, Calif. – Pasadena, Calif. – Phoenix, Ariz. – Pittsburgh, Pa. – Pompano Beach, Fla. – Portland, Me. – Portland, Ore. – Richland, Wash. – Rochester, N.Y – Salt Lake City, Utah – San Antonio, Texas – St Louis, Mo. – Shreveport, La. – Springfield, Pa. – Toronto, Ontario, CANADA – Tulsa, Okla.

imc

SERVO MOTOR-GENERATORS FOR INSTANT ERROR-SIGNAL RESPONSE

A significant result of Induction Motors' creative engineering program in recent years is the growing series of precision servo motor-generators . . . Sizes 8, 11, 18 (shown above) plus sizes 10, 15, and 20.

These units constructed to meet the latest applicable MIL specifications covering extreme environmental conditions incorporate the design objectives of light weight, high performance, and reliability at reasonable cost.

The high torque-to-inertia characteristic of these servo motor-generators offers high acceleration and immediate accurate response to error signals.

GENERATOR CHARACTERISTICS
Input: 18V 400 cps, 1.65 watts
Voltage gradient per 1000 RPM: 0.27V
Temperature range: —55°C. to +150°C.
Null Voltage (max): 0.015V rms
Phase shift: within 10° of Reference

SIZE 8
O.D. = 0.750
L = 2-1/32
J = 0.75 gm cm²
Wt. = 2.86 oz.

MOTOR CHARACTERISTICS
Input: 18V 400 cps 4.7 watts per phase
Torque at Stall: 0.42 oz. in.
No Load Speed: 6200 rpm
Power Factor: 0.875
Theoretical Acceleration at Stall: 39000 rad/sec²

Design characteristics of IMC's Size 8 to Size 20 series of servo motors and servo motor-generators, as well as full technical data on IMC DC motors and dynamotors; axial, vaneaxial, and centrifugal blowers; hysteresis and torque motors; synchros and solenoids, can be obtained by writing on company letterhead to IMC's Sales Engineering Dept. All IMC components can be designed to your particular requirements with the same precision and accuracy.

imc Magnetics Corp.
Formerly: Induction Motors Corp.
570 MAIN STREET/WESTBURY, L.I., N.Y./EDGEWOOD 4-7070 • 6058 WALKER AVE./MAYWOOD/CALIF.

CIRCLE 50 ON READER-SERVICE CARD

WHAT'S NEW

(CtE, April '58, p. 42) against several major electronics companies for a contract to devise an advanced defense anti-missile system for the Air Force. Other members of the team: Olin Mathieson, Bausch & Lomb, and United Shoe Machinery.

Lockheed, one of the nation's top 45 industrial firms, had 1958 sales of $962,679,000, nearly a third in missiles and space vehicles. It employs 56,500, has plants in nine states and Mexico and Japan.

Schlumberger, Inc., Acquires Mid-Century Instrumatic

Shortly after stockholders approved a change in its name, from Mid-Century Instrumatic Corp. to Computer Systems, Inc., this analog computer maker transferred 80 percent of its stock to Schlumberger, Inc. The new association bodes well for both companies. For Schlumberger, it means the addition of a new facility that had done exceedingly well since it was formed in 1950 (gross annual sales at present: $1 million) in the field of analog computers and simulators, and computer accessories; and for Computer Systems, it means an investment, by Schlumberger, of more than $3 million to improve production, increase personnel, and further work in R&D.

One of Computer Systems' latest developments, an analog computer facility for making research studies at an oil refinery, was described briefly two months ago (CtE, May, p. 205).

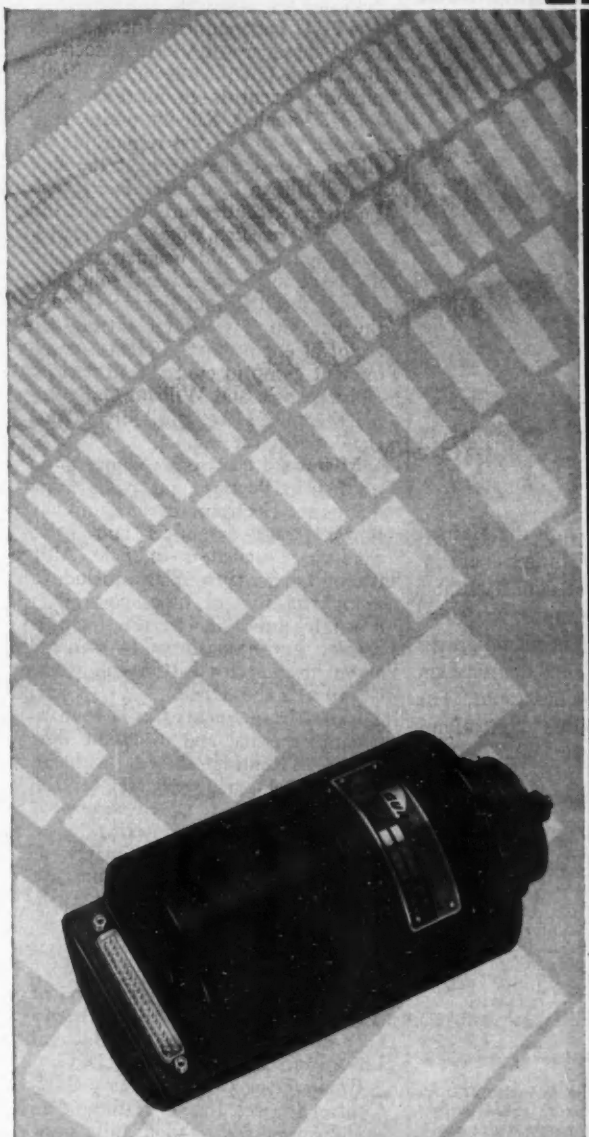
New Companies in the Field

Computer Sciences Corp., formed by a number of authorities in automatic programming to assist computer users and manufacturers in making feasibility studies and doing both applications programming and problem analysis for scientific and data-processing work—in Los Angeles. The firm is already at work on its first job: development of a business-data compiler for Minneapolis-Honeywell, to be used with the new Honeywell 800 system. Among the officers are Fletcher Jones, formerly general supervisor of integrated data processing at North American Aviation's Columbus Div., president; Roy Nutt, formerly head of automatic programming at United Aircraft Corp., design and development director; and Robert L. Patrick, formerly with Corp. for Economic & Industrial Research, director of appli-

Now there are 2 ways to read angles...

Photoelectrically with a Gurley Encoder

Optically with a Gurley UNISEC®



Angles may now be read photoelectrically with the Gurley Precision Shaft Position Encoder. The information can be transmitted anywhere, in digital form.
Write for Bulletin 8600.

You can read shaft positions to one second of arc —directly— with the Gurley UNISEC,® an Optical Coincidence Reading System, complete with a precision glass circle.
Write for Bulletin 7500.

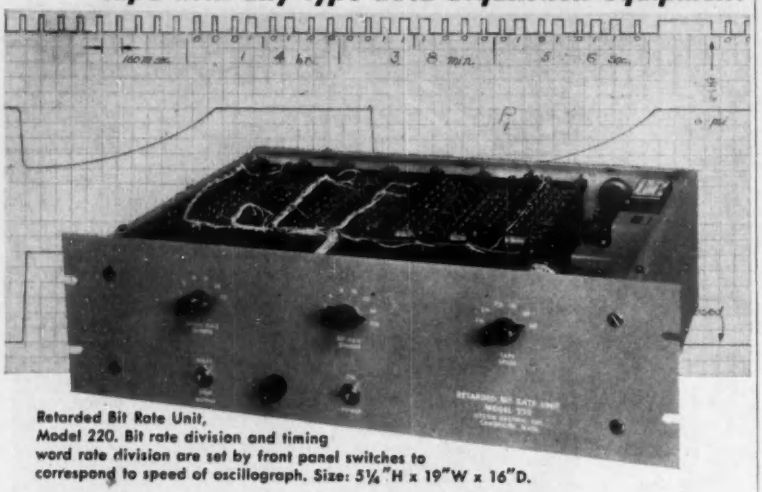
GURLEY

W. & L. E. GURLEY, 537 FULTON STREET, TROY, NEW YORK

CIRCLE 51 ON READER-SERVICE CARD

New RETARDED BIT RATE UNIT

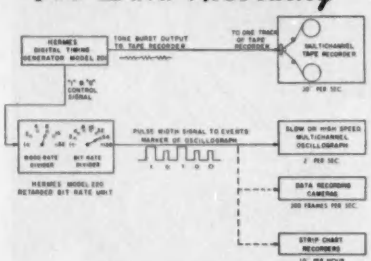
provides simultaneous indexing of magnetic tape with any type data acquisition equipment



Retarded Bit Rate Unit, Model 220. Bit rate division and timing word rate division are set by front panel switches to correspond to speed of oscillograph. Size: 5¼"H x 19"W x 16"D.

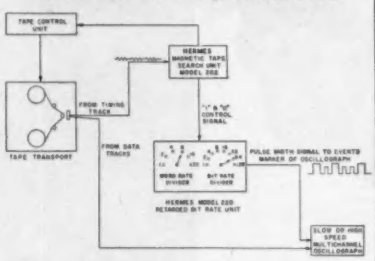
The Retarded Bit Rate Unit, Model 220, when used with the Hermes Digital Timing Generator, Model 201, or Airborne Digital Timing Generator, Model 206A, provides a universal timing system with format signals suitable for recording on magnetic tape, slow or high speed oscillographs, recording cameras, strip chart recorders, etc. During the periods of data reduction the Model 220 is used with the Hermes Model 202 Magnetic Tape Search Unit for re-recording the true signal from magnetic tape to oscillographs. The Model 220 is also available packed in a ½ ATR Box for airborne applications.

For Data Recording



The Digital Timing Generator, Model 201, supplies a tone burst binary coded decimal signal for recording on one channel of a multichannel tape recorder. The Model 220 receives the "1" and "0" control signals from the Model 201 and converts this to a pulse width and pulse height binary coded decimal signal for recording on oscillographs or other data recording equipment.

For Data Reduction



The Retarded Bit Rate Unit, Model 220, receives the tone burst binary coded decimal signal from the tape through the Magnetic Tape Search Unit, Model 202, and converts this to a pulse width and pulse height timing signal which is re-recorded on the oscillograph. The bit rate and word rate are adjusted to conform with the speed of the oscillograph regardless of the speed of the tape transport.

Write for Technical Bulletin 220

The new name for HYCON EASTERN, INC. is

Hermes Electronics Co.

75 Cambridge Parkway • Dept. J • Cambridge 42, Massachusetts

CIRCLE 52 ON READER-SERVICE CARD

WHAT'S NEW

cations programming. Nutt is widely known for his development of the Share Assembly Program programming language for large-scale computers.

S-F-D Laboratories, Inc., a new R&D subsidiary of Varian Associates, Inc., headed by three former Bell Laboratories scientists—in northern New Jersey. Joseph A. Saloom, president of the new company, was responsible for all microwave tube work at the Bell branch labs in Laureldale, Pa.; Joseph Feinstein, executive vice-president and director of research, worked on crossed-field amplifiers and magnetrons, and did research in plasma and solid-state physics for Bell; and Jerome Drexler, the new firm's vice-president and director of engineering, headed a development group in crossed-field devices. Robert Angle and William C. Sylvernal share R&D responsibility in mechanical engineering.

Microwave Electronics Corp., to do research in, develop, and manufacture microwave electronic devices, initially traveling-wave amplifiers and backward-wave oscillators—in Palo Alto, Calif. Longer-range plans include a proprietary line of tubes covering a broad frequency range. President is Stanley F. Kaisel, formerly manager of engineering for Litton Industries' Electron Tube Div.

Flow Measurements Corp., to manufacture thermal and ultrasonic flow meters—in Kensington, Md. In charge of the development program for the new firm, which is closely associated with Weinschel Engineering, electronic testing equipment maker of Kensington, is Don R. Pardue. He has been with Weinschel since 1958.

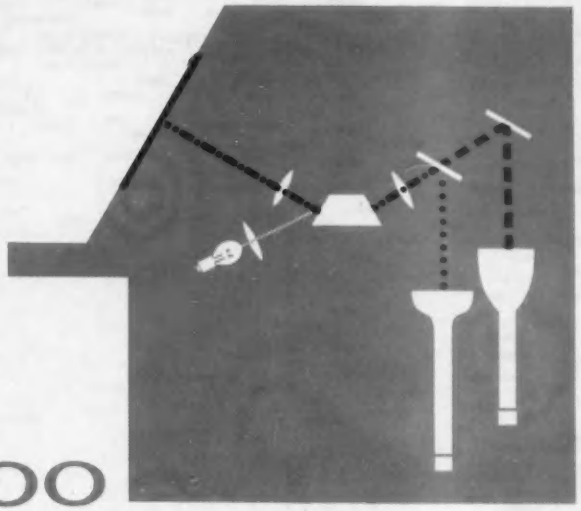
Now It's—

Aerospace Industries Association of America, Inc., formerly Aircraft Industries Association of America, Inc., of Los Angeles and Washington, D. C.

CompuDyne Corp., formerly CDC Control Services, Inc., of Hatboro, Pa., the change made to more fully show an interest in the concept that integrates computer techniques and electronic control instrumentation to simulate dynamic conditions and automatically regulate process variables.

Raytheon Co., formerly Raytheon Mfg. Co., the change made to reflect a broader engineering scope. This is Raytheon's second name change; its first name, in effect up until 1925, was American Appliance Co.

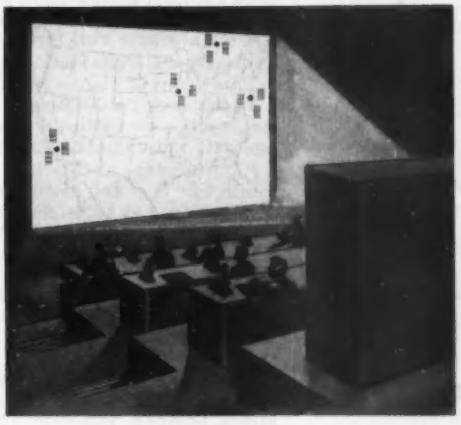
IMC Magnetics Corp., formerly Induction Motors Corp. of Westbury, N. Y., the change made to indicate IMC's growth and diversification. Just



S-C 2000

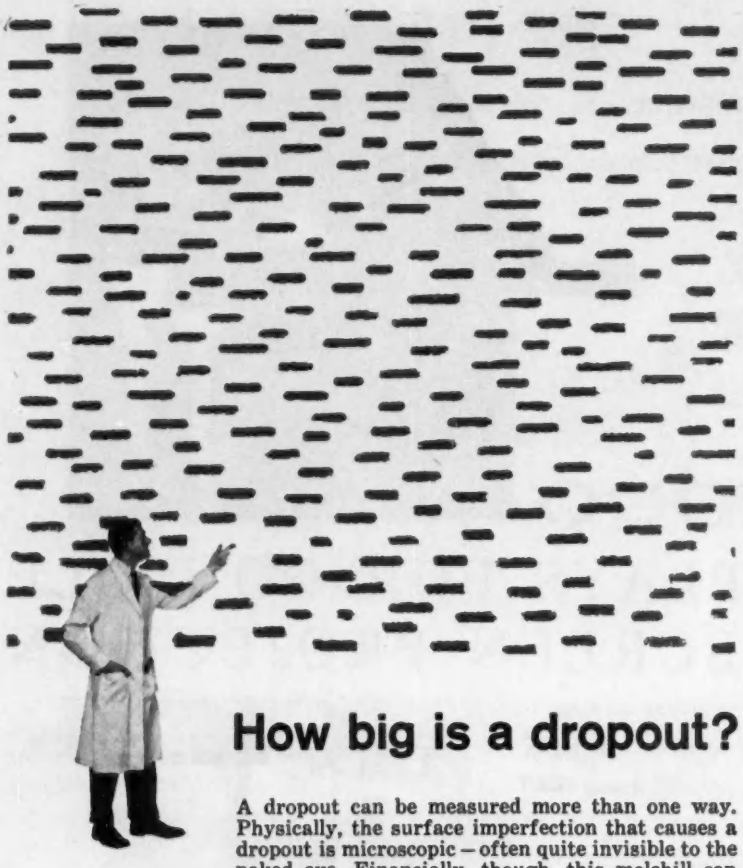
BRIGHT DISPLAYS FOR CONSOLE OR LARGE SCREEN PROJECTION

Bright, fail-safe, flicker-free display of alpha-numeric, symbolic and graphic data at high speed . . . simultaneously with PPI-type radar presentations . . . is now provided by S-C 2000 Bright Displays. Displayed data may be viewed in normal ambient light directly on the screen of the S-C 2000 console, or may be projected for group viewing on a large theatre-type screen. For air traffic control and military applications, maps may be displayed concurrently with radar targets and their identifying symbols, assisting the operator in geographic orientation. The fail-safe feature of S-C 2000 Bright Displays results from use of the xerographic process which allows the last frame displayed to be retained permanently, even in event of complete power failure. Send for more complete information concerning S-C 2000 Bright Displays. Ask for Bulletin 7-C. Write today: Stromberg-Carlson — San Diego, 1895 Hancock Street, San Diego 12, California.



GENERAL DYNAMICS
STROMBERG-CARLSON DIVISION

CIRCLE 53 ON READER-SERVICE CARD



How big is a dropout?

A dropout can be measured more than one way. Physically, the surface imperfection that causes a dropout is microscopic – often quite invisible to the naked eye. Financially, though, this molehill can become a mountain – may cost you thousands of dollars from a single error.

That's why our customers invariably demand perfection from our EP Audiotape, the extra precision magnetic recording tape. They just can't afford dropouts.

Audio Devices' battery of Automatic Certifiers is one of the unique means used to make sure EP Audiotape always meets customer specifications. The Automatic Certifier records and plays back every inch of the EP Audiotape under test. These tests can be so demanding that if the tape fails to reproduce just one test pulse out of the 40 million put on a single reel, the entire reel is rejected. There are no ifs, ands, or buts.

This is one of many special quality-control operations to which EP Audiotape is subjected. From raw material to hermetically sealed containers, every reel gets individual attention.

EP Audiotape quality is so well verified by instruments like the Automatic Certifier that every reel is guaranteed to be defect-free! For more information write for free Bulletin T112A. Write Dept. TC, Audio Devices, Inc., 444 Madison Avenue, New York 22, N. Y.

TYPE **EP audiotape** TRADE MARK

AUDIO DEVICES, INC.
444 Madison Ave., N. Y. 22, N. Y.
In Hollywood: 840 N. Fairfax Ave.
In Chicago: 5428 Milwaukee Ave.
Export Dept.: 13 East 40th St., N. Y., 16
Rectifier Division: 620 E. Dyer Rd., Santa Ana, Calif.

CIRCLE 54 ON READER-SERVICE CARD

before it changed its name, the company made its latest acquisition: Mason Electric Corp. of Los Angeles, producer of aircraft and heavy-duty rotary switches.

IMPORTANT MOVES BY KEY PEOPLE

George Downsbrough Is the New President of SAMA

Scientific Apparatus Makers Association has elected George A. Downsbrough, president of Boonton Radio Corp., president, succeeding Richard E. Welch, vice-president of W. M. Welch Mfg. Co., Chicago, who has held the post for the past two years. A former director at large of SAMA and a past-chairman of its Industrial Instrument Section, Downsbrough joined Boonton in 1942, became president and treasurer in 1952. The election was held at the 41st annual meeting of SAMA, at White Sulphur Springs, W. Va.

Associate Professorships for Lefkowitz, Mergler

Among those advanced in a series of faculty promotions at Case Institute recently were Irving Lefkowitz and Harry W. Mergler, both appointed associate professors of mechanical engineering. Lefkowitz, the subject of a CtE *Control Personality* sketch in June 1958 (page 17), joined the Case faculty in 1953 as a research associate, received his PhD degree there in 1958. This summer, he and Case's Prof. Donald P. Eckman will direct a short course in dynamic analysis for chemical engineering teachers, sponsored by Foundation for Instrumentation Education & Research and the Process Control Subcommittee of AIChE.

Mergler, a consulting editor of CtE, is another one of its "personalities" (Sept. '58, p. 23). He, too, holds a PhD degree from Case; he became a member of the faculty in 1956. This July he will conduct a 10-day short course at Case in numerical feedback control, his specialty.

A full professorship was conferred on John R. Martin, whose area is electrical engineering. He joined the Case Faculty as an instructor in 1920.

Dufford to Direct Work with Clients of Genesys

Donald E. Dufford has been named head of applications engineering at

(Continued on page 176)

A **NEW** DIMENSION IN DIGITAL "READOUT" . . .

THE INSTRUMENT THAT READS ITSELF!

THE CUBIC TALKING METER

A world of exciting applications with a dimension never before engineered into precision digital instrumentation:
A METER THAT TALKS!

- ✓ Where physical set-up factors prevent line-of-sight meter readings
- ✓ Where safety requires that the eyes stay on the work area
- ✓ Where voice "readout" creates previously unknown convenience
- ✓ Where a combination of sight and sound gives impression impact

NOW **Instrumentation with two sensory dimensions . . . an edge-lighted digital readout and a clear human voice!**

Conversion of any phenomenon of science to a DC voltage . . . pressure, temperature, depth, volume, salinity, countless weights and measures . . . provides a typical application for the Cubic Talking Meter, the instrument that reads itself!

Vocameter—the Talking Meter—is the newest addition to Cubic Corporation's line of quality Digital instruments. Write today for information about the Talking Meter and these other precision instruments: Voltmeters, AC Converters, Ohmmeters, Scanners, Ratiometers, Printer Controls, Preamplifiers.

CUBIC CORPORATION

5575 Kearny Villa Road, San Diego 11, California

Electronic Engineering With a Dimension for the Future

CIRCLE 55 ON READER-SERVICE CARD CIRCLE 56 ON READER-SERVICE CARD→

When designing,
brush

testing or monitoring . . .

YOU CAN RECORD RESULTS BETTER WITH BRUSH

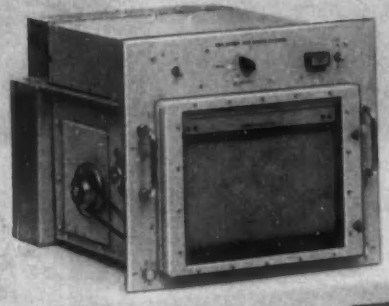
All Brush Recording Systems reflect advanced concepts in design that mean exceptional versatility, accuracy and reliability in your data collecting operations.

Your most exacting requirements can be met by these *direct writing* systems whether military or industrial. They display information *instantly*—give you precise data for quick decisions. You control the data you need, exclude the extraneous, and have optimum flexibility for future applications not yet contemplated.

Widest choice of equipment in the industry. Ink, electric or thermal writing . . . curvilinear or rectilinear readout . . . horizontal or vertical presentation . . . chart speeds from 10 inches/day to 4 feet/second . . . complete selection of amplifiers . . . rack mounted, bench top or portable configurations.

A pioneer in instrumentation since 1930, Brush has always built for ruggedness and precision. Installations are right. Operating manuals contain clearly written instructions. Your personnel are trained properly.

In designing, testing or monitoring you can get better results from Brush *Ultralinear* Recording Systems. Let's talk it over. Set a date. We'll be there.



Write for free informative booklet, "New Concepts in Recording." Contains helpful ideas and suggestions.

brush INSTRUMENTS

DIVISION OF CLEVITE CORPORATION

37TH AND PERKINS CLEVELAND 14, OHIO

Factory branches, service and warehousing at Arlington, Va., Boston, Cleveland, Los Angeles, San Francisco and Seattle; engineering representatives in all key locations.

PRECISION GYROS

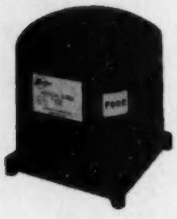
A Proven Kearfott Capability. The increasing use of Kearfott gyros and gyro platforms in today's missile programs, underscores the company's leadership in gyro design and production. Such missile projects as the Atlas, Bomarc, Polaris, Snark, Subroc and Talos rely on Kearfott gyros or gyro platforms, as do the majority of manned aircraft now in service.

FLOATED RATE INTEGRATING GYROS. High accuracy miniature gyros specifically designed for missile use. The performance characteristics of these gyros are superior to any comparably-sized units available today. Hermetically sealed within a thermal jacket and ruggedly designed for adaptability to production methods. These gyros operate efficiently at unlimited altitudes. More precise performance characteristics can be provided in the same dimensions.

TYPICAL CHARACTERISTICS

Mass Unbalance:
Along Input Axis: 1.0°/hr maximum untrimmed
Standard Deviation (short term):
Azimuth Position: 0.05°/hr
Vertical Position: 0.03°/hr
Drift Rate Due to
Anisoelasticity: Steady
Acceleration: .015°/hr./g² maximum
Vibratory Acceleration: .008°/hr./g² maximum
Damping: Ratio of input angle to output angle is 0.2
Characteristic Time: .0035 seconds or less.
Weight: 0.7 lbs.
Warm-up Time: 10 minutes from −60°F
Life: 1000 hours minimum

VERTICAL GYROS. Provide accurate vertical reference in the form of two 400 cps synchro signals proportional to the sine of gimbals' displacement about pitch and roll axes. Gravity-sensitive vertical reference device provides electrical signals directly to torque motors which maintain gyro spin axis perpendicular to earth's surface. Hermetically sealed, they are unaffected by sand, dust, sun, rain, salt spray, humidity or fungus conditions as specified in MIL-E-5272A.



TYPICAL CHARACTERISTICS

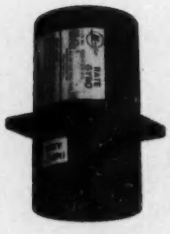
Repeatability to Established Vertical: To within a cone of half angle equal to 15 minutes of arc (± 8 minutes typical).
Free Drift Rate in 5 minutes Time: 2.5° maximum at room temperature. 3.75° at −54°C and + 71°C.
Erection Rate: 2.5°/Min.
Initial Erection: The gyro will erect to within ± 1° of established vertical in 60 seconds time after application of power at room temperature.
Vibration and Shock: The gyro will meet above characteristics after vibration of 0.060" total excursion cycling between 10 CPS and 55 CPS for 4.5 hours. Shock test in accordance with MIL-E-5272A Procedure 2.
Operating Life: 1000 hours minimum.

FREE GYROS. Provide extremely accurate reference in the form of electrical output signals proportional to displacements about outer axes. With 360° of freedom about outer axes (inner axis freedom depends on the unit involved), these gyros may be mounted to give output signals of either pitch, roll or yaw. Shock and vibration resistant, they are equipped with quick-starting motors for applications in high performance missiles and aircraft.

TYPICAL CHARACTERISTICS

Free Drift Rate: Within 0.5° in one minute time.
Shock: The gyro operates satisfactorily without damage after 60g shock of .015 seconds duration.
Hermetically Sealed: These instruments are hermetically sealed and are not affected by sand, dust, sunshine, rain, humidity or fungus conditions.
Operating Temperature Range: Gyros operate in ambient temperatures below −20°C to + 100°C. A maximum of 3 minutes of operation at 400°F will not damage these gyros nor impair their accuracy.
Weight: 5.5 lbs. approximately.

SPRING RESTRAINED RATE GYROS. Almost universally applicable in missile and aircraft designs demanding precise angular rate measurements in environments of extreme shock and vibration. Fluid filling provides added immunity to shock and vibration, reduces bearing friction in AC types and potentiometer wiper friction in DC types. Kearfott design advances permit 30 second warm-up, overcome fluid viscosity variations resulting from ambient temperature change. These gyros are single-degree-of-freedom, viscous damped, spring restrained, with gimbals supported by precision bearings. Compensatory damping mechanisms eliminate need for accessory heaters.



TYPICAL CHARACTERISTICS

Maximum Rate (°/sec.): 45-1000
Natural Undamped Frequency (cps) (± 10%): 16
Damping Ratio (of critical) over Temperature Range: .35 to .80
Operating Temperature Range (°F): −65 to +185
Vibration: 12 g's @ 20-2,000 cps
Shock (Motor Running): 60 g's for 6.5 milliseconds
Warmup Time (Sec.): 30
Weight (lbs.) (max): 1.5
Gyro Time Constant (Sec.): .012

Engineers: Kearfott offers challenging opportunities in advanced component and system development

Roll Stabilized Directional Gyro

3 Gyro—4 Gimbal Gyro Reference

25 Pound Inertial Platform

Kearfott | A GENERAL PRECISION COMPANY

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
A subsidiary of General Precision Equipment Corporation

Sales and Engineering Offices: 1500 Main Ave., Clifton, N. J.
Midwest Office: 23 W. Calendar Ave., La Grange, Ill.
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 CIRCLE 57 ON READER-SERVICE CARD

SQUEEZING HIGH POWER INTO small packages

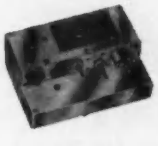
Unhampered by traditional thinking, TELECHROME engineers have developed an entirely new concept in telemetering equipment — unequalled in compactness, ruggedness and dependability.

TELEMETERING TRANSMITTERS

FM/FM or PDM/FM Crystal Controlled

215 to 260 Megacycles

Model 1472



4" x 1.5" x 2.7"
2 Watts

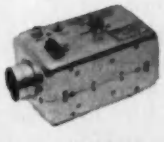
Model 1463

5 1/32" x 3 3/16" x 4"
15 to 30 Watts

Model 1462

6" x 4 1/16" x 3 1/16"
50 to 80 Watts

Model 1466A



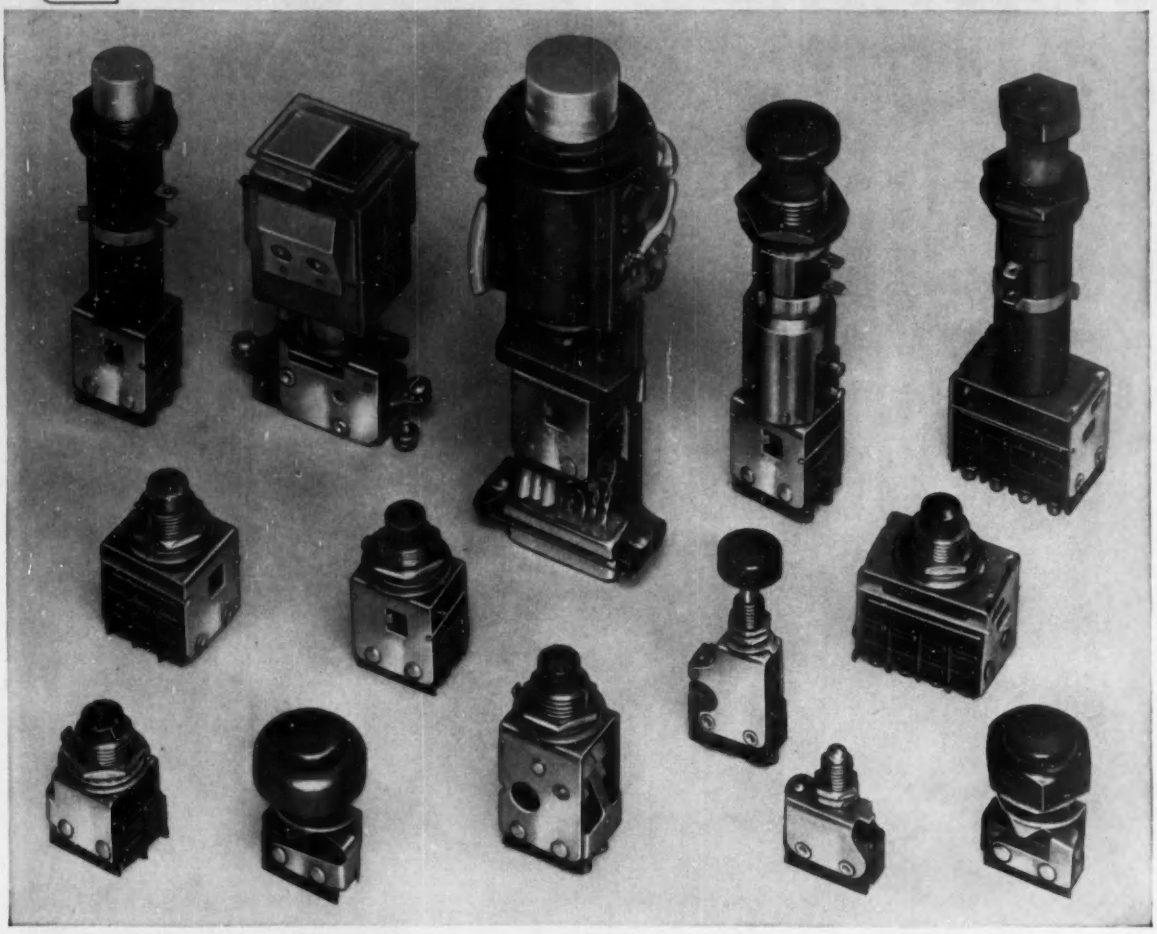
6.5" x 4" x 3.25" RF Amplifier
2 watts in — 100 watts out

SUB-CARRIER OSCILLATOR, Model 800C — 1.5" x 1.9" x 2.45"

Deviation stability ±1% of band width. Deviation linearity less than 1% of band width under all conditions measured from a straight line drawn between end points.

TELECHROME

MICRO SWITCH Precision Switches



Need pushbutton switches?

Here is a sampling of a very wide choice

These assemblies are typical of many different series of MICRO SWITCH pushbutton switches. Each series offers many variations of electrical and operating characteristics.

Operational characteristics include: momentary action, lock-down, alternate action, two-position alternate action, and magnetically held. Direct control of up to fourteen double-throw circuits is offered. Short and long button strokes can be provided. Sealed switches are available when protection is required from oil, water, sand, or salt spray. Special shock and vibration-resistant features are built into switches for rugged duty service. Switches with illuminated pushbutton display are available. These include switch devices with interchangeable modular indicator and pushbutton units.

Experienced engineering assistance to help you select the pushbutton switch best suited to your requirements is as near as your MICRO SWITCH branch. There is no obligation.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

0.01%

IMPEDANCE COMPARATOR

For Testing Components Automatically or Semiautomatically

TYPE 1605-A IMPEDANCE COMPARATOR . . . $790

Also available, the Type 1605-AS3, with a 10-to-1 increase in sensitivity. This special design can measure impedance differences as small as 0.001% and phase-angle differences of 0.00001 radian. Price on request.

★ NO MANUAL BALANCING NECESSARY: Impedance-magnitude and phase-angle differences between unknown and standard are indicated directly on two panel meters.

★ Impedance Ranges: Resistance 2Ω to 20 MΩ; Inductance 20 μh to 10,000h; Capacitance 40 μμf to 800 μf (to 0.1 μμf with reduced sensitivity).

★ Full-Scale Meter Ranges:
Impedance-Magnitude Difference: ±0.3%, ±1%, ±3%, ±10%
Phase-Angle Difference in Radians: ±0.003, ±0.01, ±0.03, ±0.1

★ Accuracy is 3% of full scale (±0.009% on smallest range)

★ 100c, 1 kc, 10 kc, 100 kc internal test frequencies.

★ D-C voltages proportional to percentage deviation from standard are provided for control of automated sorting systems.

★ Excellent guard circuitry permits long cable runs for remote measurements.

★ No excess switches or complex controls.

★ Constructed for reliable service, long life.

★ May be rack or bench mounted.

G-R Impedance Comparator is the heart of a highly-automated system designed under Signal Corps contract by the Inland Testing Laboratories of Morton Grove, Illinois. This system measures and records in sequence insulation resistance, capacitance, and power factor of 12,000 capacitors of several different values. All three parameters for each capacitor are measured without need of resetting controls.

Comparator metering voltages are fed into a digital voltmeter and converted into digital form for IBM-card recording. The program will provide detailed information concerning reliability and life cycles of capacitors operating under various voltages and environmental conditions.

Centralab uses G-R Impedance Comparators in production testing miniature ceramic-disc and feed-thru capacitors produced at their Milwaukee Plant. The speed and ease with which the Comparator makes these measurements permits Centralab to maintain continuous quality-control checks without adding significant manufacturing time or cost to their product.

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS

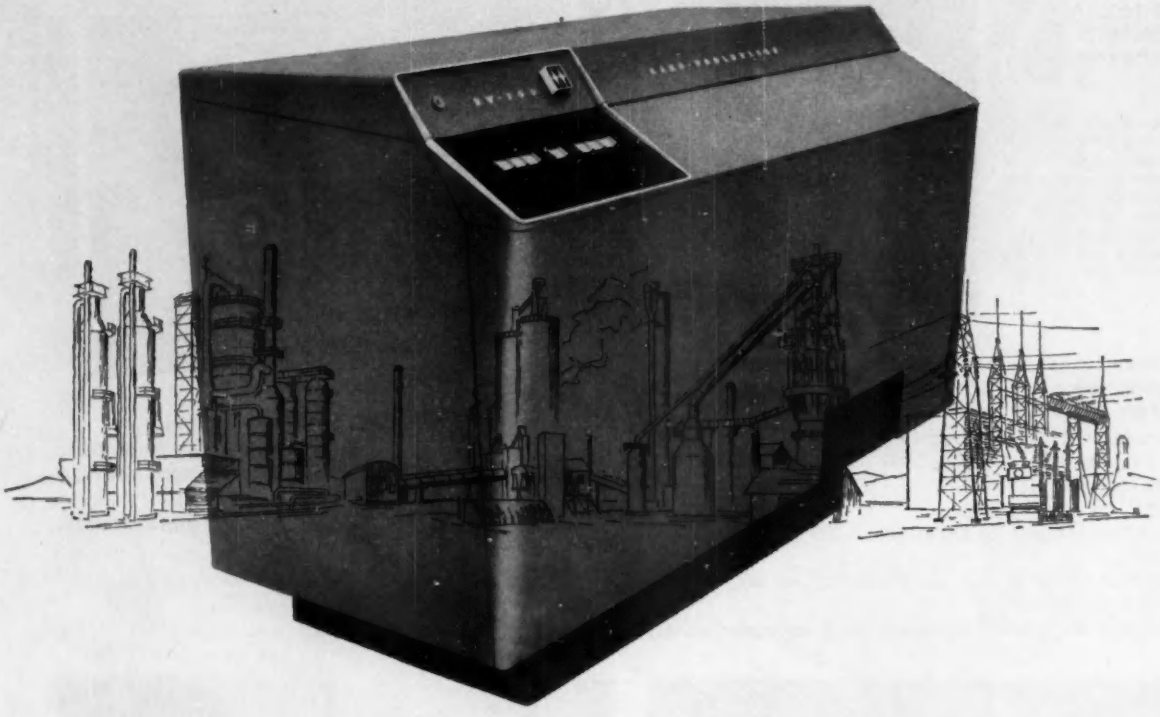
1919
First Worm-Driven
Precision Capacitor

NEW YORK AREA	CHICAGO	PHILADELPHIA	WASHINGTON, D.C.	SAN FRANCISCO	LOS ANGELES	IN CANADA
Broad Ave. at Linden Ridgefield, N. J. N. Y. WOrth 4-2722 N. J. WHitney 3-3140	6605 W. North Ave Oak Park Ill. Village 8-9400	1150 York Rd. Abington, Pa. HAncock 4-7419	8055 Thirteenth St. Silver Spring, Md. JUniper 5-1088	1182 Los Altos Ave Los Altos, Cal. WHitecliff 8-8233	1000 N. Seward St Los Angeles 38, Cal HOllywood 9-6201	99 Floral Pkwy. Toronto 15, Ontario CHerry 6-2171

CIRCLE 60 ON READER-SERVICE CARD

In a Class by Itself

FOR CLOSED-LOOP CONTROL
AND AUTOMATIC DATA REDUCTION



The RW-300

DIGITAL CONTROL COMPUTER

OPERATING SYSTEMS incorporating the RW-300 for on-line control and data reduction are demonstrating these tangible benefits: *reduced costs, increased output, improved quality.*

HIGH RELIABILITY, inherent in the advanced design of the RW-300, is being proven by thousands of hours of dependable operation.

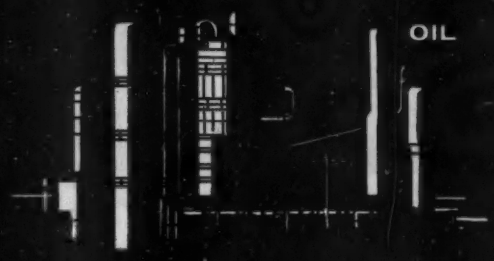
SYSTEMS ENGINEERING staff, experienced in the analysis of complex control and data reduction problems, is assisting industry with applications of the RW-300 in chemical, petroleum, steel, cement, electric power, and other fields.

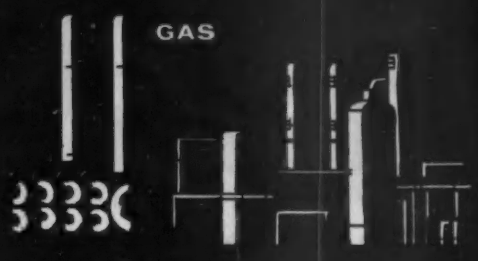
NATION-WIDE SERVICE organization is providing skilled maintenance for this completely developed, production engineered, and thoroughly tested piece of *industrial* equipment.

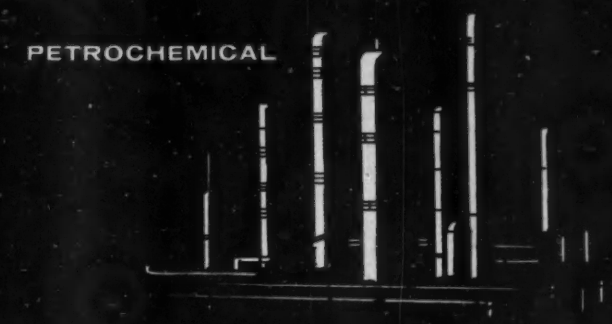
For further information, call or write: Director of Marketing, The Thompson-Ramo-Wooldridge Products Company, P.O. Box 90067 Airport Station, Los Angeles 45, California, OSborne 5-4601.

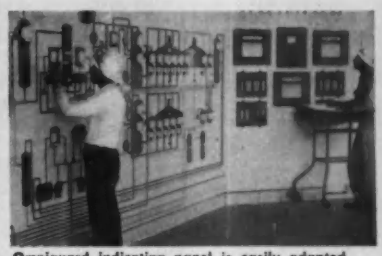
THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS COMPANY

a division of ***Thompson Ramo Wooldridge Inc.***



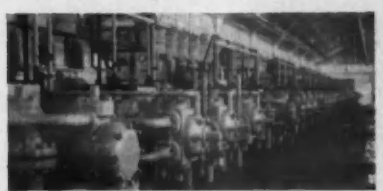






Omniguard indicating panel is easily adapted to miniaturized instrument panel installations for central control.

Detectors provide continuous temperature monitoring of drive motors for shipping pumps.



Omniguard system protects this bank of compressors installed at a natural gas cycling plant.

Oil company power plant uses Edison Omniguard system to protect generating equipment from overheating.

THOMAS A.

EDISON

omniguard system provides reliable, flexible temperature monitoring for oil, gas and petrochemical industries

Throughout your process, wherever temperature is critical, the Edison Omniguard system can protect vital equipment and output quality. It is the simplest and most flexible temperature monitoring system devised.

Plug-in detector units may be installed at key points throughout the process. They can be added or switched without disturbing the system. Typical detector locations include motor and motor bearings in shipping pumps, compressors and generating stations. Individual alarm settings on each point can be changed at any time without special tools.

Indicating panel can be located in central control room, for complete overall process monitoring by a single individual. Alarm system positively identifies trouble point.

The complete system is designed for utmost reliability. There are no moving parts, nothing to wear out.

Edison engineers will be happy to provide assistance in designing the most efficient system to meet your requirements.

For additional information write for publication 3036-C.

Thomas A. Edison Industries
INSTRUMENT DIVISION
38 LAKESIDE AVENUE, WEST ORANGE, N. J.

EDISON ENGINEERING OFFICES ARE LOCATED IN: WASHINGTON—BALTIMORE; CHICAGO; DALLAS; DAYTON; LOS ANGELES

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This Test Stand handles 12 units simultaneously, all temperature compensated to −55°C to +150°C. Also tests output voltage, phase shift and linearity. Test Stand has a speed accuracy of .01%, transformation accuracy of .001% and phase shift accuracy of 2 minutes.

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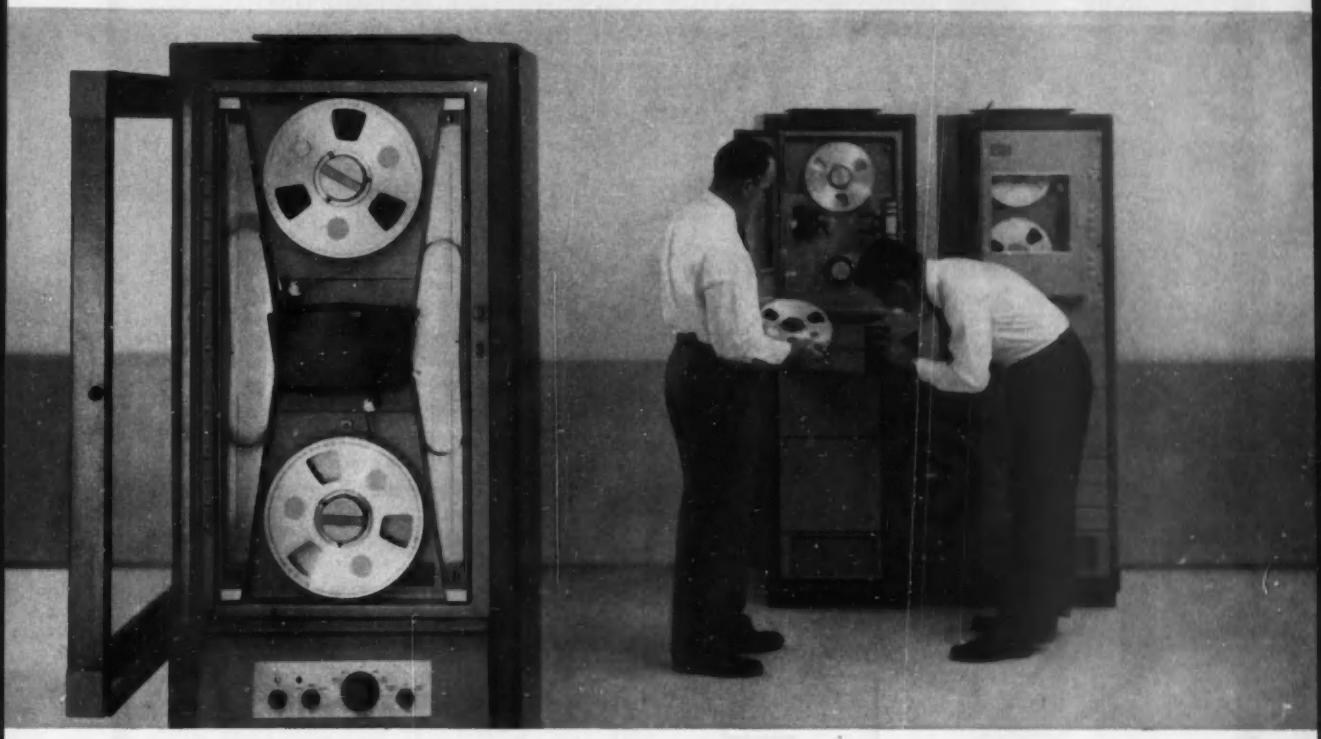
Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms.
Contact Mr. Robert Burns, Personnel Manager, in confidence.

 CIRCLE 63 ON READER-SERVICE CARD

A five-foot bookshelf is a 10-minute task



for this AMPEX FR-300 digital tape handler

Yes, the Ampex FR-300 could easily "read" or "write" the digitalized equivalent of a five-foot bookshelf in less than ten minutes. Why is this important? Because today's big computers accept and present large quantities of data in a hurry. Their time may be worth as much as $1000 per hour. Keeping one waiting for data is expensive.

As the fastest available magnetic tape handler for "on-line" duty with these machines, the FR-300 maximizes utilization of high-speed digital computers. By placing two 6-bit alpha-numeric characters side by side on one-inch tape at 150 ips and 300 bits per inch, it achieves 90,000 character-per-second transfer rates.

Short, predictable start/stop times reduce buffer requirements and Ampex dependability further increases computer efficiency.

Ampex offers digital systems complete from head to tape (the sensational new Ampex Computer Tape, by the way) because a system designed as an integrated whole will out-perform those built from tape transports, magnetic heads, amplifiers and tape secured from a variety of different suppliers.

For lesser computers and "off-line" duty on such auxiliary digital equipment as converters, data plotters, printers, etc., the FR-400 and FR-200A tape handlers (not shown) provide a wide wide range of lower transfer rates. And in the background above are two fine analog recorders, the FR-100A and FR-1100, to remind you that only Ampex offers such a broad line of fixed and mobile recorders for instrumentation and control.

A folder on the FR-300 is available if you would like one.

First in magnetic tape instrumentation

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AMPEX INSTRUMENTATION DIVISION
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First with a fully operating computer-controlled pilot plant, Consolidated Systems now offers automatic control from the first order closed loop to full-scale automation in refineries, chemical plants, and pipe lines. Adaptation of "Microplant" unattended pilot plant equipment and philosophies to other problems... tieing together analytical equipment, control equipment, and computer systems . . . can be accomplished now through the unique experience and capabilities of Consolidated. For full information, write for Bulletin CEC 3019-X3.

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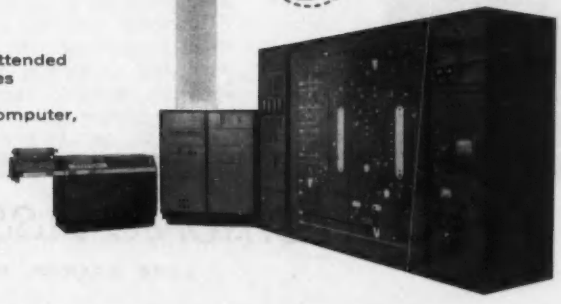
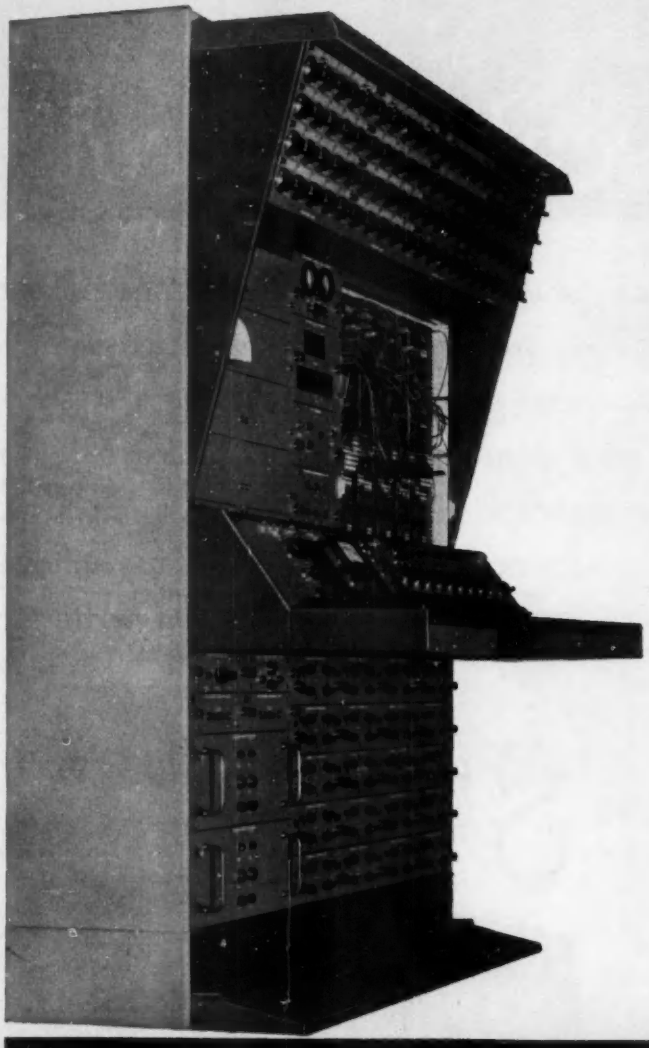
The Microplant, an automatic, unattended pilot plant for process data, includes utilities, reactor, and distillation. Instrumentation includes digital computer, digital programmer, logger, scanner, product-composition analyzers, controllers, and graphic panel.



CIRCLE 66 ON READER-SERVICE CARD

EAI PACE Computers Put Central Control At Your Fingertips

SOLUTIONS COME FASTER, EASIER WHEN YOU SIT IN THIS CHAIR



You can expect, (and be sure you'll get) the utmost in working accuracy and fine construction from every PACE computer. It's simple, we build more in – you get more out. But you will have to actually sit at the console to appreciate some of its very finest points.

Take our control panel for instance. *Every* important control is within easy reach from a sitting position. Including *all* coefficient potentiometers. Quick adjustments are easy, and the panels are sloped for restful operation through the very longest day.

Examine the patch panel. Modular grouping of components reduces patching time to one third that of other systems. Keeps cords short, eliminates tangle and clutter. And for legibility it is the model of the industry.

The completely electronic Digital Voltmeter reduces by two thirds the time needed for setting coefficient potentiometers. Presents the component address immediately too. No guesswork needed here.

Within easy view, central overload indicators tell visibly and audibly when improper operation of any component occurs *including* non-linear equipment.

Words could describe the fully Automatic Scanning of all components recorded by the High Speed Printer at 200 lines a minute. And the merits of Extended Read-out which allows you to select any component in the system for read-out by merely touching a button. But we think you should see this in action.

These are the subtle refinements developed in years of designing, building and operating more general purpose analog computers than all other computer manufacturers combined. We call it Human Engineering. Again, you will have to *see* for yourself. We will be glad to arrange a demonstration or send you literature. Write today!

ELECTRONIC ASSOCIATES Incorporated

ELECTRONIC ASSOCIATES INC.

LONG BRANCH, NEW JERSEY

The European Common Market: Its Impact on Control

After only six months of operations, it's too early to measure the total impact of the recently formed European Common Market, an economic union of France, West Germany, Italy, Belgium, The Netherlands, and Luxembourg. But one fact shapes up: **control makers in countries outside the market face an eventual freezout.**

The European Economic Community, officially formed on Jan. 1, 1959, has two basic objectives: to abolish all tariffs between its members and to maintain a common tariff wall against imports from outside the economic bloc. Just what this means in terms of trade increases can be seen by looking at a predecessor group, the European Coal and Steel Community, formed in 1952. An experimental reduction of tariffs on coal, iron ore, and steel boosted steel tonnage traded between the six member countries by 169 percent, increased trade in coal tonnage by 42 percent. It was so successful that the idea was extended to a common market.

Mass Market

Long-term expectation is that the common market will replace the individual existing markets—the biggest covers 52 million people—with a combined market of 165 million people, so that American mass production techniques might be applicable in Europe for the first time. To achieve this, member countries will eliminate tariffs between themselves over the next 15 years.

The first half of this period has been divided into three steps: one, two and a half, and four years. In the first year, customs duties between members of the common market will be reduced by 10 percent. Reductions of at least 5 percent will be made in the next steps. At the start of the second seven-and-a-half-year period, the members will work out a timetable to reduce all remaining tariffs to zero.

Import Tax

Common import tariff to be imposed upon outsiders interested in selling to common-market members will be the arithmetic mean of the duties in effect between members on Jan. 1, 1957. For instruments and control equipment, such tariffs varied from a low 8 percent in Germany, through 10 percent in the Benelux countries and 15 to 25 percent in Italy, to France's high tariff of 20 to 25 percent. Although the final tariff rate is not yet settled, **experts estimate that the final import tax on instrument and control equipment will be close to 15.25 percent.**

Member countries plan to introduce this tax on a similar timetable. The schedule calls for a 30-percent reduction in the difference between the common tariff and present tariffs in the first year; and a 30 percent reduction of the remainder in the next two and a half years.

Wider Scope

But the scope of the common market embraces more than just the abolition of tariffs among its members. Included in its long-term objectives are **some significant sociological changes, such as free interchange of labor, pooling of resources to help underdeveloped countries, and a common nuclear power plant.**

1958 trading figures for the common-market bloc showed that it is primarily an exporter of instruments and control equipment. According to the Office of European Economic Community, exports of instrumentation and control of the six-member countries totaled $152 million in 1958; imports added up to only $52 million (p. 77).

To countries on the outside, however, the common market bloc is causing much anxiety. These outsiders see the ultimate loss of a young growing outlet for instrumentation. The big problem: how to cut product prices so that they will be competitive with import-free instruments manufactured inside the common market. Here's how countries inside and outside the bloc view implications of the newly operative economic community:

German Reaction

Germany: Already a major supplier to other common market countries, German makers expect their share of the business to increase. But most people don't look for sharp increases right away. Said an AEG spokesman, "Trade between common-market countries will undoubtedly increase, but national preferences will continue for some years."

Enthusiasm for the common market is not overly strong in West Germany. For one thing, that country's growth in instrumentation and control business has been phenomenal: a 64-percent increase in the last three years. Some Germans feel that their country could continue to do well without the common bloc; still they are glad of another opportunity to make European trade grow.

German membership in the market will have more influence on outsiders. With low tariffs (some down to 6 percent) and no import quotas, Germany imported a considerable volume of instrumentation, primarily from the U.S. Now, the higher common-market tariffs will be imposed on

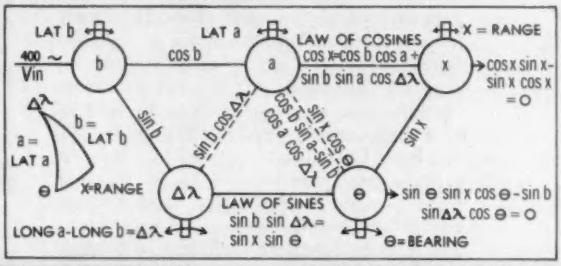
advanced
PRECISION COMPUTING RESOLVERS
for
Cascaded Resolver Systems

SIZE 8 FEEDBACK WINDING RESOLVERS

These resolvers are designed for use with transistorized amplifiers and permit the solution of spherical triangles in a size 8 cascaded resolver chain.

Functions of the spherical triangle which can be produced are indicated in the schematic below. More complex trigonometric functions, as well as systems involving coordinate axis transformation, can be generated with the use of these resolvers.

Accuracy: Functional error .1% or less; winding perp. ±5'. Electrical characteristics: Input voltage 15v400~ (stator); output voltage 13.7v (rotor); phase shift (stator as primary) 20.5°; output voltage 13.7v (compensator); Zro 234 + j596; Zso 244 + j548; Zcompensator 237 + j553; max. null voltage 1 mv/v.

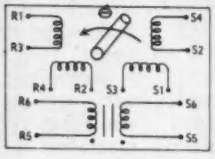


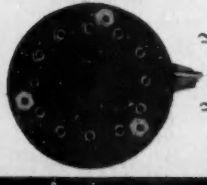
SIZE 11 AMPLIFIERLESS RESOLVER FOR ANGULAR DATA TRANSMISSION

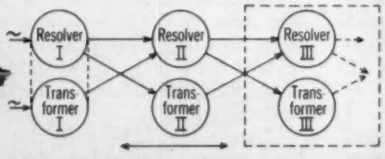
These size 11 resolvers incorporate an integral transformer which simulates a resolver function at maximum coupling. They are used in the typical chain application indicated below for angular data transmission. In this particular application, the output information can be servoed at either end of the chain.

Quick disconnect allows ease in harnessing.

Accuracy: ±5' of arc or less; winding perp. ±5'. Electrical characteristics: Input to EITHER rotor or stator. Input voltage 115v1600~; output voltage 110v both stator and rotor as primary; phase shift (stator primary) 1.1°; phase shift (rotor primary) 1.9°; Zso (nom.) 990 + j13500; Zro (nom.) 1150 + j13500.







SIZE 11 RESOLVER TRIMMED FOR ZERO PHASE SHIFT CONTAINS ALL COMPENSATION IN 2¼" LENGTH

The YZC-11-E-1 precision computing resolver has been developed for use in a cascaded, amplifierless resolver system at 900~.

These units have been trimmed to provide zero phase shift and compensated for transformation ratio stability, under temperature, when working into their iterative impedance.

Accuracy: Functional error .1% or less; winding perp. ±5'. Electrical characteristics: Input voltage (stator) 40v900~; output voltage (rotor) 33.2v; phase shift 0; max. null voltage 1 mv/v.

Also ready for delivery is an equivalent, compatible pancake resolver. By its use, differential information from an inertial platform may be obtained and introduced into the system.

ENGINEERS—Join the leader in the rotating components field. Write David D. Brown, Director of Personnel, Dept. N7

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goods coming in and, as a clincher, there's now a possibility of import quotas.

French growth

France: Traditionally, French control makers have always feared German competition. The lowering of French import tariffs on German instruments scares some Frenchmen, but most are counting on the newly dynamic French industry growth (running as high as 25 percent a year) to take the sting out of German no-tariff competition.

Outsiders, again, are those most concerned. France imported over $24 million worth of instrumentation, primarily from the U.S. and Britain. The common tariff, say outsiders, will cause those two countries to lose the French market. **Experts say that imports from America will drop off sharply.** They feel strongly that, if U.S. manufacturers do not set up shop within the common market area, they will be frozen out.

English Fears

Great Britain: As the closest outsider, Great Britain feels it has much to lose by the common market. Because of fear of a freeze-out, British control makers are following two philosophies: 1) some are setting up manufacturing facilities in the common market area, and 2) some are strenuously extending markets to Canada so that production can be increased sufficiently to cut production costs, to make British-made goods competitive price-wise with common-market-made instruments, despite the common tariff.

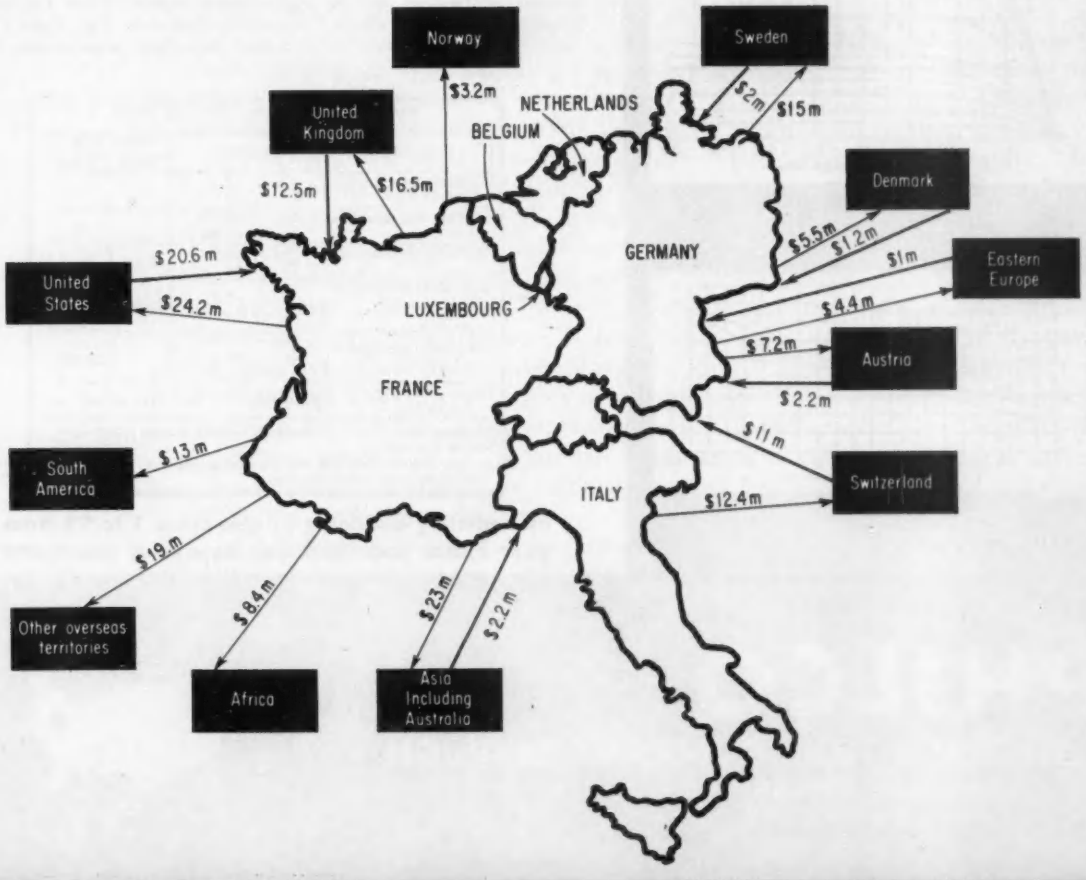
The Solartron group of companies, for example, is following the first philosophy, and is doing it in three steps. First, sales outlets of associated companies (located in the common-market area) are being strengthened. Secondly, manufacturing facilities are being established in France, initially for the assembly of instruments from imported piece parts. Finally, full-stage production will be set up, particularly for custom-made equipment, for common-market sale.

In addition, the Solartron group is setting up an R&D team in Munich, Germany, to facilitate a flow of technical innovations between Britain and Germany. An export agency, which other United Kingdom firms can use, will help pour products into the common market through Solartron sales outlets.

EMI Electronics is following the second approach. It sees drastically increased production and thus lowered manufacturing costs as the best way to get their products into the common-market area. The increased production, EMI feels, will come from markets in North America, particularly Canada.

U. S. Problems

United States: U.S. makers seem set to lose the most in dollar volume by the common market. They have the same problems as their British counterparts, as well as two additional ones: higher wage rates for labor in the U.S. and a tougher (because of geographic distances) servicing problem.



PHILCO

Silicon Surface Alloy Transistors

For Reliable Performance at High Temperatures

These field proven Philco Silicon Transistors (SAT*) permit complete transistorization of military and commercial circuits that are subjected to high ambient temperatures . . . with excellent performance at junction temperatures ranging from —65° C to +140° C.

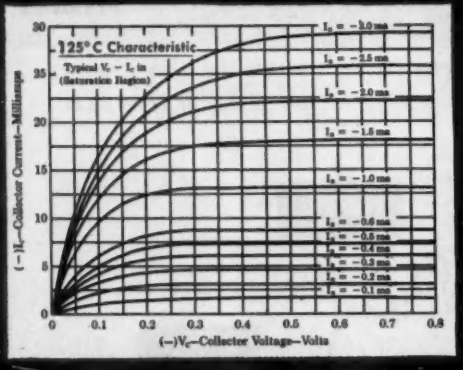
Type 2N495 is a general purpose silicon transistor designed for amplifier and oscillator applications at frequencies through 15 mc.

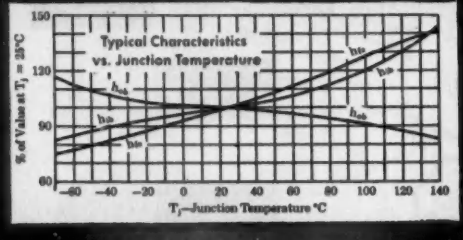
Type 2N496 is specifically engineered for high speed switching circuits. The frequency at which beta equals unity (f_t) is typically 18 mc. It gives the designer the advantages of low saturation resistance and low voltage operation, at high junction temperatures.

These units are environmentally tested in accordance with MIL-T-19500A.

Complete information will be supplied upon request. Write Lansdale Tube Company, Division of Philco Corporation, Lansdale, Pa., Dept. CE-759.

**Trade Mark Philco Corp. for Surface Alloy Transistor*





CHARACTERISTICS OF TYPES 2N495 and 2N496			
CHARACTERISTIC	CONDITION	TYPICAL VALUE 2N495	TYPICAL VALUE 2N496
Current Amplification Factor, h_{fe}	$V_{CB} = -6$ v, $I_E = 1$ ma	20	
Current Amplification Factor, h_{FE}	$V_{CE} = -0.5$ v, $I_C = -15$ ma		16
Output Capacitance, C_{ob}	$V_{CB} = -6$ v, $I_E = 1$ ma	7 $\mu\mu$f	7 $\mu\mu$f
Maximum Frequency of Oscillation, f_{os} max.	$V_{CB} = -6$ v, $I_E = 1$ ma	21 mc	
Frequency for Beta = 1, f_t*	$V_{CB} = -6$ v, $I_E = 1$ ma, f = 4 mc		18 mc
Cutoff Current, I_{CBO} or I_{EBO}	V_{CB} or $V_{EB} = -10$ v	.001 μa	.001 μa

Maximum Power Dissipation—150 mw

Maximum Collector Voltage 2N495—25 V, 2N496—10 V

*f_t (the frequency at which beta is unity) is typically 85% of the alpha cutoff frequency.

Immediately available in quantities 1 to 99 from your Philco Industrial Semiconductor Distributor

PHILCO

LANSDALE TUBE COMPANY DIVISION

LANSDALE, PENNSYLVANIA

TRANSISTOR CENTER U.S.A.

Control
ENGINEERING

JULY 1959

GUEST EDITORIAL:

Because of the significance of the contributions that NEMA's new Industrial Automatic Systems Section will make to the control field, we have invited H. W. Cory, chairman of the section's scope committee, and assistant manager of the Control Department, Allis-Chalmers Mfg. Co., to editorialize on the new section this month.
—Ed.

New Era Needs NEMA Standards

Feedback control of the conversion and use of electrical power in industrial applications has brought on a new era of industrial control, revealed to users in the form of exciting new techniques and apparatus, such as program control, data logging, data processing, and computing control. Users recall how the advent of the regulated utilization of electrical power in the mid-30's radically improved the productivity of complex manufacturing operations. Anticipating that the new-era systems will yield similar increments of improvement, users are demanding the systems. Makers, naturally delighted to meet the demand, nevertheless sense the dangers of supplying the systems without accepted standards of manufacture and performance. Working through their National Electrical Manufacturers Association (NEMA), ten electrical manufacturers (see page 30 for details) have now pooled their systems standardization activities in an Industrial Automatic Systems Section, created this June by NEMA.

Standardization in the control field is a perpetual task, for control equipment develops in never-ending cycles. Over the years NEMA has undertaken the task presented by electrical control equipment and has performed outstanding service to both maker and user. The diversity of technologies involved in the new-era automatic systems set the stage for a new NEMA task of great breadth. The diversity of technologies will draw definitions from technical societies such as AIEE and IRE and from trade associations such as Electrical Industries Association, Aircraft Industries Association, and the Scientific Apparatus Makers Association. Because automatic systems are composed of combinations of system components drawn from the diverse technologies, any new standards must establish component compatability. Recent efforts of AIEE, IRE, and ISA to standardize ways of testing and describing the static and dynamic characteristics of components may help in this part of the task. Standards of system performance, required because the components are selected on the bases of function and performance, depend on the performance requirements of the machinery or operation under the control of the automatic system. NEMA's new section must draw such standards from industry.

The nucleus of ten electrical manufacturers recognizes the magnitude of its task. It welcomes the cooperation of technical societies and trade associations and it invites the active participation of other manufacturers of automatic systems.

H. W. Cory

Doing Pulsed or "Fast" Circuit Work?

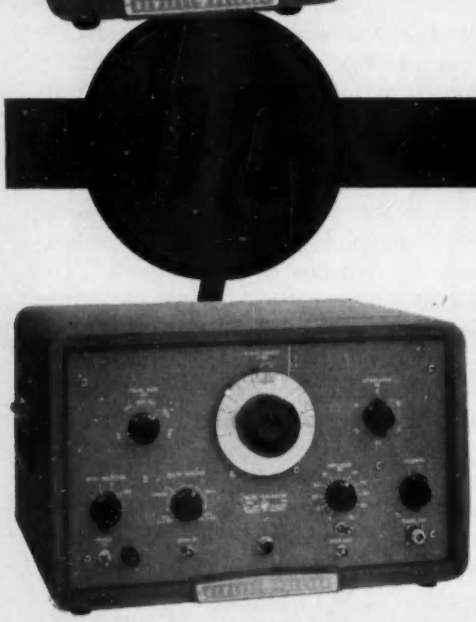
Square Wave Generator

1 cps to 1 MC; 0.02 μsec rise time

211A Square Wave Generator. Versatile, wide range instrument for testing oscilloscopes, networks, video and audio amplifier performance, modulating signal generators, measuring time constants. Offers simple control of electronic switchers; is also convenient for indicating phase shift, frequency response and transient effects.

Special features include two separate outputs — a 7 volt, 75 ohm circuit for television work and a 55 volt, 600 ohm output for high level work. Both outputs offer full amplitude variation. May be operated free-running or externally synchronized with positive going pulse or sine wave signal of 5 volts minimum amplitude. Compact, weighs only 25 lbs. Cabinet model, $300.00; rack mount model, $305.00.

Pulse Generator



0.07 to 10 μsec pulses, 0.02 μsec rise time

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Structural Diagrams— *A Short-cut to Analog Computer Circuits*

Any control engineer can derive a structural diagram of his system that translates immediately to an analog computer circuit. The system differential equations need never be written; only the published characteristics of the components and their interconnection diagram are needed. The structural "blocks" represent seven operations basic to analog computing (including nonlinearities).

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AEG—Institut fuer Automation,
Frankfurt-Main, Germany

It is not necessary to solve for the characteristic differential equation of a system to set up an analog computer circuit for test or analysis. The computer circuit can be constructed, instead, directly from a "structural diagram" derived only from the mathematical relationships that describe the elementary components of the system and their interconnections. This technique is applicable to both linear and nonlinear systems. The seven basic operations encountered are defined in Table I, along with suggested symbols for the structural diagram "blocks" that represent them.

The dead time block covers systems described by difference equations, and the integrating block meets the requirement of integrating action, generally preferred in analog computers.

Structural diagrams can be transformed under the same rules that hold for normal block diagram transformation. For inversion, however, the input and out-

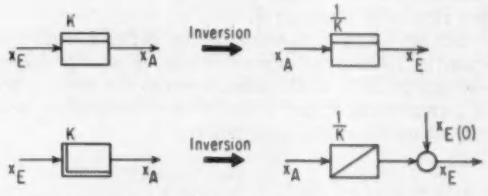


FIG. 1. Structural blocks (see Table I) can be inverted by interchanging input and output. Inverting D-block is special case that requires adding initial conditions to the resulting I-block.

TABLE I
THE STRUCTURAL BLOCKS

NAME OF BLOCK	OPERATION	EQUATION	SYMBOL
Summing point (S-point)	addition or subtraction	$X_A = X_{E1} \pm X_{E2}$	
Proportional block (P-block)	multiplication by a constant	$X_A = K\,X_E$	
Integrating block (I-block	integration	$X_A = K\int_0^t X_E\,dt$	
Differentiating block (D-block)	differentiation	$X_A = K\frac{dx_E}{dt}$	
Dead-time block (DT-block)	dead-time generation	$X_A(t) = K\,X\,(t-T_t)$	
Function block (F-block)	function generation	$X_A = f(X_E)$	
Multiplying block (M-block)	multiplication of two variables	$X_A = X_{E1}\;X_{E2}$	

put of the block must be interchanged while the operation of the block is inverted.

Figure 1 shows the inversion of a P-block and a D-block. Inversion of the D-block results in an I-block; but, since on inversion

$$x_A = k\frac{dx_B}{dt}$$

becomes

$$x_B = \frac{1}{k}\int_0^t x_A dt + x_{B(0)}$$

the initial condition term $x_{B(0)}$ must be calculated.

In operation, each element of the circuit diagram is transformed separately into its respective block without ever considering the system differential equations. This is done for two kinds of systems on the following pages. Once established, the structural diagram, can be converted directly into analog computer hardware. A *P*-block becomes a potentiometer, the summing point a summing amplifier, an *I*-block an integrator, and an *F*-block a function generator, and so on.

Computer circuits formulated from structural diagrams are equally applicable to mechanical or electrical systems. Table II shows block representations for common electrical and mechanical system components. The constants required for setting up these operations on a machine are easily derived from published technical data for the components, as is shown in Table III for the system of Example 1.

Besides being a convenient step between circuit diagram and computer circuitry, the structural diagram, like any other block diagram, serves as the starting point of conventional frequency-response or root-locus investigations on the system parameters.

Table II—Common Electromechanical System Components

COMPONENT	EQUATION	STRUCTURAL BLOCK
Loop of a network	$v = v_1 + v_2 + \cdots$	S—point
Node of a network	$i = i_1 + i_2 + \cdots$	S—point
Inductance	$v = L\frac{di}{dt}$	D—block
Resistance	$v = R.i$	P—block
Capacitor	$v = \frac{1}{C}\int_0^t i\ dt$	I—block
Electronic amplifier	$v_A = f(v_E)$ $i_A = f(v_E)$	F—block (for small variations, P—block)
Emf of generator or counter-emf of motor	$e = K.n\phi$	M—block (if n or ϕ are constant, P—block)
Torque of a motor	$M = K\ i_A K\phi$	M—block (if i_A or ϕ are constant, P—block)
Magnetic flux	$\phi = f(i_E)$	F—block (for small variations, P—block)
Force equation, torque equation	$P = P_1 + P_2 + \cdots$ $M = M_1 + M_2 + \cdots$	S—point
Speed equation	$v = v_1 + v_2 + \cdots$ $\omega = \omega_1 + \omega_2 + \cdots$	S—point
Acceleration	$P = m.\dot{v}$ $M = \theta\dot{\omega}$	D—block
Attenuation, viscous friction	$P = dv$ $M = d\omega$	P—block
Spring	$P = c\int_0^t v\,dt$ $M = c\int_0^t \omega\,dt$	I-block

Two examples show how to derive structural diagrams

EXAMPLE 1. MOTOR SPEED CONTROL

Figure 2 shows a simple speed-control system with M_L a load torque disturbance. The motor field sets up a rotational speed n at which the tachometer generator provides an output

$$e_T = K_T \cdot n$$

A potentiometer taps off a fraction of this voltage for feedback

$$v_J = K_J \cdot e_T$$

These elements are represented in Figure 3 as proportional blocks 1 and 2. The error signal is generated by subtracting the tachometer voltage v_J from the set-point voltage v_S. Summing point a represents the equation

$$v_D = v_S - v_J$$

FIG. 2. Schematic of simple speed-control system

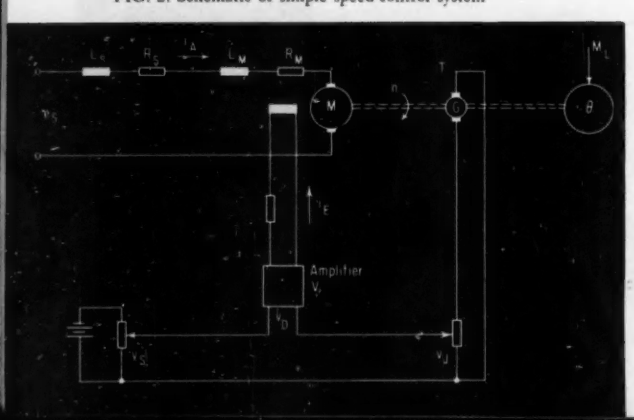


Figure 4 shows the characteristics of an amplifier whose output over the linear range is given by $i_E = i_{E(0)} - K_v v_D$, and represented by *P*-block 3 and summing point *b*.

The amplifier output current generates the motor magnetic flux ϕ, where $\phi = f(i_E)$. *F*-block 4 represents this relationship.

A constant dc source (e_S) with a source inductance and resistance of L_S and R_S supplies the motor armature. The back emf of the motor e_M, and v_R and v_L (the voltage drops across resistors $R_S + R_M$ and inductances $L_S + L_M$), are connected at the summing point c by the equation

$$v_R = e_s - e_M - v_L$$

The multiplying block 5 gives the motor back emf from the equation $e_M = K_M \cdot \phi \cdot n$. The armature current i_A is calculated from the voltage drop across R_S and R_M (*P*-block 6), while the differentiating block 7 determines the voltage developed across L_S and L_M.

Motor torque M_A, a product of armature current and magnetic flux (block 8), divides into two components.

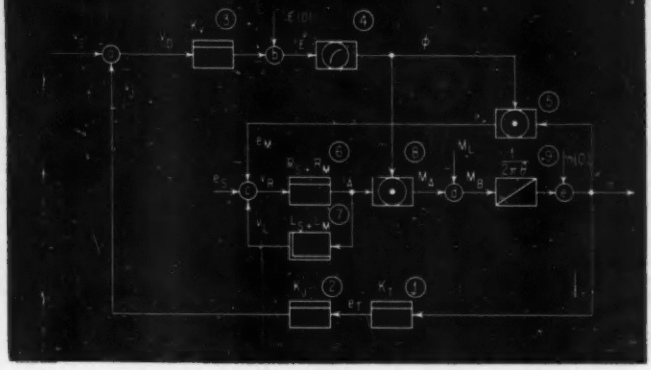


FIG. 3. Structural diagram analog representation of speed control.

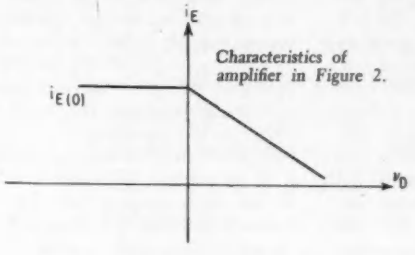


Table III—Constants for Blocks in Example 1

BLOCK	CONSTANT	GIVEN TECHNICAL DATA
1	$K_T = \frac{e_T}{n}$	e_T = rated emf of tach generator n = rated speed of tach generator
2	K_J	K_J = attenuation of potentiometer
3	K_V	K_V = amplification of amplifier V
4	$f(i_E)$	$f(i_E)$ = magnetizing characteristic of motor M
5	$K_M = \frac{e_M}{\phi n}$	e_M = counter emf of motor at rated speed and flux ϕ = rated flux of motor n = rated speed of motor
6	$K_6 = \frac{1}{R_S + R_M}$	R_S = resistance of voltage source R_M = resistance of motor armature
7	$K_7 = L_S + L_M$	L_S = inductance of voltage source L_M = inductance of motor armature
8	$K_A = \frac{M_A}{\phi i_A}$	M_A = motor torque at rated armature current and flux ϕ = rated flux of motor i_A = rated armature current of motor
9	$K_9 = \frac{1}{2\pi\theta}$	θ = inertia of motor armature plus load
b	$i_{E(0)}$	$i_{E(0)}$ = quiescent current of amplifier
c	e_S	e_S = constant dc voltage
d	$n(0)$	$n(0)$ = speed at the time 0

One maintains equilibrium with the load torque M_L and the other provides armature and load acceleration. The accelerating torque ($M_a = M_A - M_L$) is used to derive the speed n, where

$$n = \frac{1}{2\pi\theta}\int_0^t M_a dt + n(0)$$

θ is the motor and load inertia and $n(0)$ the speed prior to the initial disturbance. Integrating block 9 and summing point e complete the structural diagram.

Detailed block constants in Table III show that only simple manipulation of published technical data is needed to prescribe this system analog.

EXAMPLE 2. MECHANICAL LEVER SYSTEM

Figure 5 shows two simple mechanical systems interconnected by a lever. Application of a force P_z imparts a velocity v_2 to the mass m_2 in the second system. The force equation for the first system is

$$P_z = P_{m1} + P_{d1} + P_{h1}$$

where P_{m1} is the accelerating force on m_1, P_{d1} a frictional force, and P_{h1} the force imparted to the lever.

The lever transmits to the second system a force

$$P_{h2} = \frac{-h_1}{h_2} P_{h1}$$

which is the summation of the frictional, spring loading, and mass accelerating forces for system 2. Other equations necessary are:

$$P_{m1} = m_1 \frac{dv_1}{dt}$$

$$P_{d1} = d_1 v_1, \; P_{d2} = d_2 v_2$$

$$P_c = c\int_0^t v_2 dt \text{ and } v_1 = -\frac{h_1}{h_2} v_2$$

Figure 6 shows the conversion of these equations into a structural diagram with an input P_z and output v_2. Reversals of sign between P_{h1} and P_{h2} and v_2 and v_1 are symbolized by a summing point with one (negative) input.

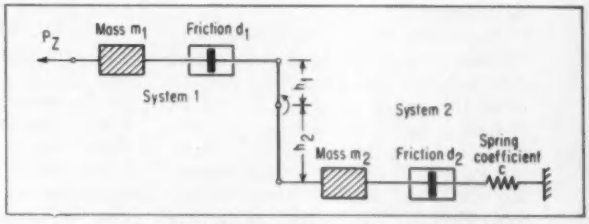


FIG. 5. Mechanical linkage system to be analoged.

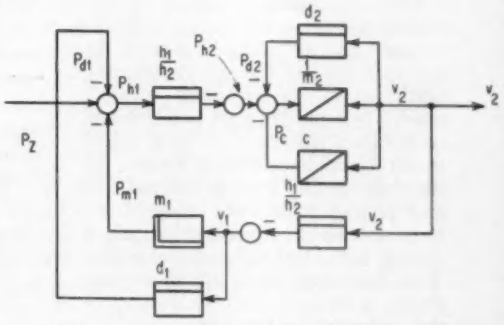


FIG. 6. Structural diagram for system of Figure 5.

Revamped Motors, Controls Up Tinning Line Output

D. H. JENTER, Reliance Electric & Engineering Co.

Faced with the need for increasing the production of an electrolytic tinning line, the United States Steel Corp. decided to modernize rather than replace the existing facility. The line involved was one of three "Ferrostan" lines installed at the Irvin Works Plant during World War II. Originally designed to operate at 600 fpm, the line had been modified earlier and its speed increased to 700 fpm. The latest modernization aimed for a top speed of 950 fpm with improved speed, tension, and position control. In addition, recoilers were to be added to the line to facilitate the production of tinplate in coiled form.

A processing line such as this is basically a constant-torque application; hence, optimum performance called for a change in the electrical system from "voltage-and-field" to "all-voltage" control. It was determined that the drive bridle motor, the lead unit of the "center section", could be safely operated with its field preweakened to sustain the additional speed, and that the many tachometers used as reference could be retained.

Approximately 20 3-hp motors were applied to individual conductor and deflector rolls throughout the line, to offset the torque reduction caused by operating the drive bridle motor with weakened field. Such individual helper roll drives also provided easier threading and more flexible system operation. Further, four motors of varying sizes up to 15 hp were used to drive groups of "sink rolls".

Of the remaining motors in the center section, the auxiliary bridle motor (used to maintain tension in the strip passing through the electrostatic oiler) was retained without change by replacing gears and bearings in the gear reducer. The drag bridle motor (used to maintain tension in the strip moving through the pickling and plating tanks) was replaced by three specially compounded machines driving individual rolls of the bridle. The dual-series fields of these machines were cross-connected to provide inherent load-sharing.

Because of the extremely critical requirements of the entry end, new machines were applied in all cases. These machines were designed for 300-volt operation, providing 20 percent over-speed for loop replenishment and enough torque to accelerate a 30,000-lb coil from rest to 950 fpm in 5 sec. The existing Hallden shear motor was retained but its field preweakened to accommodate the shortest sheet length. The modulated loop control system used to synchronize the shear speed with that of the center section was designed with enough range to accommodate all anticipated lengths of cut. The classifier motors were not changed, but one additional motor with integrally mounted tachometer was installed to provide signals to the speed regulator. Gearing of all motors was changed.

The existing main motor-generator set contained three 75-kw generators and two 50 kw constant potential exciters. These units were adapted for use in the new system by paralleling the fields of the 75-kw generators, to obtain faster response through "forcing". The exciters on the main m-g set were not changed.

The two small existing booster m-g sets were replaced by three new sets, one containing individual generators for the motors of the entry end. Overvoltage was included in the design of these units to provide overspeed of the entry end for loop replenishment. Another new set contained booster generators for certain machines in the center section. The last set consisted of four control exciters constructed with two fields. Three of these generators excite the single-field, 75-kw main generators to give the capability of voltage reversal for jogging and regulation of zero voltage for stand-by. The remaining generator excites all main generators of the entry section. This configuration provides the capability of actually reversing the travel of the strip in the entry section automatically if required by unusual operations, such as starting with too much strip in the entry looping pit. The preset tension on the uncoiler was maintained during such reversal.

Most of the original control panels were retained, the principal exception being the motor-operated rheostat panel; this was entirely replaced to avoid restacking the resistors. The rheostat is now used only as a reference for the line speed regulator.

The wiring changes required were reasonably straightforward, consisting for the most part of deleting switching equipment, such as contactors and field-accelerating relays, whose functions were duplicated in the new regulator circuitry. Many new relays were required, but these were almost exactly balanced by the control devices that were disconnected.

The heart of the control system for this line is the regulating system. The existing system utilized regulators of the "rocking arm" variety, which not only lacked the accuracy and speed of response required, but also were becoming increasingly hard to maintain due to the scarcity of spare parts. In the new system, the regulating functions were provided by 15 packaged electronic units.

BENEFITS OF MODERNIZATION

1. **Line Standard Speed-raised from 665 to 935 fpm.**
2. **Acceleration Time from Welding Speed to Standard Speed-decreased from 25 to 8 sec.**
3. **Variation in Line Speed at Standard Speed-reduced from ±20 fpm to ±5 fpm.**
4. **Range of Over/Under Shoot on Coming up to Standard Speed-reduced from ±40 fpm to ±10 fpm.**

Control System Test Equipment

PART III: RESPONSE EVALUATION INSTRUMENTS

The first two articles in this series (CtE, March, p. 116 and May, p. 125) covered devices that only generate a test signal and systems that both generate a test signal and provide a means for evaluating control-system response. In this concluding article, Author Fuchs discusses commercially-available equipment limited to control-system-response evaluation, and various home-grown testing devices. One complete transfer function measuring system is covered that was introduced too late to be included in Part II.

ABRAHAM M. FUCHS, Boonshaft & Fuchs, Inc.

Devices for response evaluation only complete the picture of special-purpose control system test equipment. These final devices do not generate a test signal, and therefore must be mated with a test signal generator, such as those described in Part I.

The first three items described here were designed primarily for output signal evaluation in ac systems, including all those control systems whose output is a suppressed-carrier signal. (The forcing function may be a dc signal.) Items 4 through 6 are special devices for measuring phase, and can be used in frequency-response testing instead of the techniques for phase measurement already mentioned in Part II. There are two direct-reading analog phasemeters, and a digital phase-angle counter. (The digital method of phase measurement that is mechanized in the last device can be used with several manufacturers' high-speed electronic counters.) The last instrument described, Item 7, is a special converter that equips the Solartron transfer function analyzer for suppressed-carrier systems, and as such does not rigidly fit the classification of output evaluation equipment. The accompanying table summarizes the important characteristics of Items 1 through 6.

Added to Item 4 (Muirhead Instruments Phasemeter D-729-M) are a low-frequency oscillator and a tunable filter, the group of three instruments forming a complete system for measuring the amplitude ratio and phase of feedback control systems. This complete testing system was brought to the attention of the author too late to be included in the second article of this series.

Does available equipment fit requirements?

Having examined most of the special-purpose control system test equipment that is commercially available, it is well to take a broad look at the characteristics and capabilities of this equipment to estimate how well it answers requirements.

First, it is obvious that electronics is emphasized. Most of the test items in all three categories (signal generation, complete testing systems, and response evaluation) generate electronically-derived electrical test signals and evaluate control system response electronically. This heavy emphasis on electronics in part reflects its role in many control systems; but it also reflects the difficulty of satisfying pneumatic, hydraulic, mechanical, optical, etc., requirements of highly diversified industrial control applications.

To be specific, only two test items (Items 1 and 5 in Part II) provide a variable pneumatic signal, and only two (Items 6 and 7 in Part I) provide variable mechanical displacements: there are none directly applicable to hydraulic systems, or to generating varying temperature, flow, or other process

CHARACTERISTICS OF RESPONSE EVALUATION EQUIPMENT

Manufacturer	Designation	Purpose	Frequency Range	Price	Remarks
Brush Instruments 3405 Perkins Ave. Cleveland 14, Ohio	Servoanalyzer, Model BL-560	Demodulates suppressed-carrier signals and amplifies for recording	50 to 10,000 cps; carrier	$815	Also takes dc input; has precision carrier phase-shift plug-in unit; to 350 cps carrier—4 cps down 1 db; above 350 cps carrier—100 cps down 1 db
Sanborn Co. 175 Wyman St. Waltham 54, Mass.	Servomonitor preamplifier, Model 150–1200	Demodulates suppressed-carrier signals and amplifies for recording	60 to 10,000 cps; carrier	$325	Below 200 cps carrier—0.1 sec rise time; above 200 cps carrier—0.01 sec rise time; 45 cps down 3 db with recorder; $250 more for driver amplifier and power supply
Boonshaft & Fuchs, Inc. 994 Byberry Rd. Huntingdon Valley, Pa.	Visual phase-sensitive detector	Demodulates suppressed-carrier signals in conjunction with a scope	40 to 4,000 cps; carrier	$795	Zero phase shift on time lag of modulation envelope
Muirhead Instruments, Inc. 677 Fifth Ave. New York 22, N. Y.	Phasemeter D-729-BM	Measures phase and amplitude response of dc signal	dc; 0.25 to 10,000 cps	$1,990	Phase measured to ±1 deg, amplitude to ±0.2 db; 5 millivolt sensitivity; very high input impedance
Advance Electronics Lab., Inc. 451 Highland Ave. Passaic, N. J.	Phasemeter Type 405	Measures phase of dc signal	dc; 0.5 to 20,000 cps	$560	Input—0.5 to 70 volts; ±1 deg accuracy; low drift—0.001 deg per 10 hours; higher accuracy at small phase angles
	Ultra-low frequency phase angle counter	Digital method of low-frequency phase measurement	dc; 0.00001 to 1,000 cps	$948	Maximum error ±0.5 deg at less than 100 cps and more than 5-volt input; same function can be accomplished by other counters.

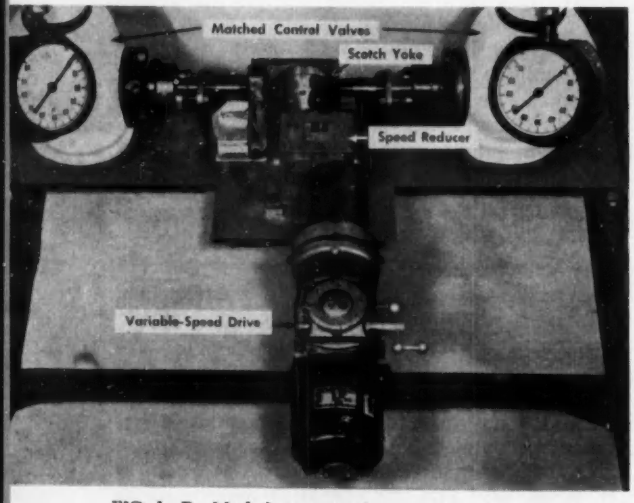


FIG. 1. Dr. Mozley's apparatus for generating sinusoidal variation of water temperature.

variables. At this point the ingenuity of the tester takes over, and a wide variety of home-grown devices have been developed. Several of these devices are discussed below.

Because of the availability of sensors with electrical signal outputs, electronic methods will undoubtedly continue to be used for response evaluation. The major problem, therefore, is in the generation of signals for special test situations.

Home-grown test equipment

An outstanding example of home-grown equipment is the apparatus for generating sinusoidal variation of water temperature; it is shown in Figure 1 and discussed by Dr. Mozley in Ref. 1. It uses a Graham variable-speed drive on a scotch yoke to convert the output of a constant-speed motor to a variable sinusoidal motion. This in turn moves two valves, one regulating hot water flow and the other ambient water flow. The resulting water mixture has a sinusoidally varying temperature for taking the frequency response of a heat exchanger.

Special devices have also been built for mechanically displacing high power levels. The Woodward Governor Co. built such a device using a high-power electric motor and a scotch-yoke mechanism. This company has also equipped a van with signal generators and output evaluation equipment (Figure 2) for control system tests at the installation site.

Electrohydraulic positioners commanded by a sinusoidal signal have also been used as high-power-level control system inputs. Their advantages are high power level over very broad frequency ranges with low distortion (no linkages), and easy variation of amplitude, zero-point, and frequency. A disadvantage is that they tie up large quantities of expensive hydraulic equipment.

With some ingenuity, very low cost equipment can be assembled to perform satisfactory frequency and transient-response tests. A switch, a voltage source, and an oscilloscope (or recorder) become a step response setup. A variable-speed motor (or motor and variable-speed transmission), a resolver (with demodulator for dc systems), and an oscilloscope (or recorder) become a frequency response test apparatus. The addition of a second resolver provides precision phase measurement.

REFERENCE

1. *PREDICTING DYNAMICS OF CONCENTRIC PIPE HEAT EXCHANGERS*, J. M. Mozley, "Industrial & Engineering Chemistry", June 1956, pp. 1,035-1,041.

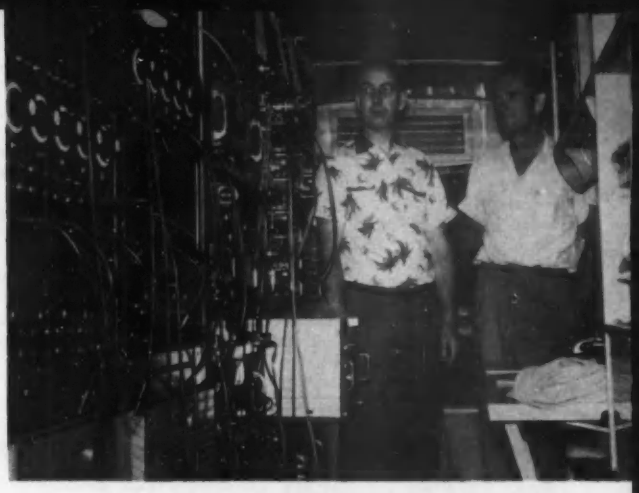


FIG. 2. Woodward Governor Co. van contains signal generators and output evaluation equipment for on-site testing of control systems.

1. BRUSH ELECTRONICS SERVOANALYZER MODEL BL-560

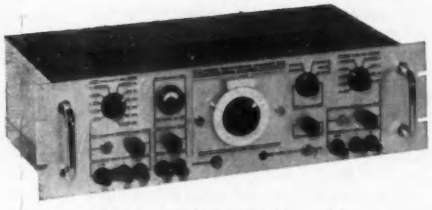


FIG. 3. Brush servoanalyzer with phase-shift resolver. Same unit is available with phase-adjust circuit to permit use of complete carrier-frequency range.

The Brush servoanalyzer, Figure 3, is a versatile device that permits the recording of the modulation envelope of a suppressed-carrier signal. As Figure 4 shows, the analyzer consists of four sections: error-signal channel, reference-signal channel, demodulator and dc amplifier, and plug-in phase-shift circuit.

The capacitor-coupled error-signal channel has a frequency range of 50 to 10,000 cps. A floating input circuit provides an input impedance of 1 megohm, and the gain is sufficient to give an overall recording sensitivity of 0.5 millivolt per mm. Input attenuators reduce this to 500 millivolts per mm where required. Overload due to quadrature is sensed and indicated on the front panel, so that the operator is assured that the error amplifier is operating in its linear range.

By means of a high-quality input transformer in the reference-signal channel, 1-megohm input impedance is attained as well as a floating input for the reference signal. Thus different grounds can be used for the error signal and reference signal. The reference channel provides the reference-level-meter excitation, as well as a calibrate signal for the error-signal channel. The output (after phase correction) drives the phase demodulator.

The demodulator is a diode-type half-wave phase-sensitive detector, whose output is filtered and then amplified by a dc amplifier. Amplifier output drives the pens. The zero can be suppressed by as much as 200 mm.

The phase-shift correction circuit is a plug-in assembly. In the analyzer shown in Figure 3, a phase-shift resolver (price of unit $195) permits carrier phase shift over the range of 0 to 360 deg (within plus or minus 1 deg) at either 60 or 400 cps. Phase is set and read by the dial on the front face of the unit. Error-channel output at any desired phase, or the phase of the error-channel output, can be accurately evaluated.

A phase-adjust plug-in unit can be used in place of the resolver. Six steps by two switches on the rear of this unit provide the necessary phase correction of the reference phase to permit operation over the 50-to-10,000-cps range. Fine adjustment by means of a knob on the front of the plug-in unit is part of the calibration procedure. Up to 170 deg of carrier phase shift is available at all frequencies.

Plug-in filters (applicable to one carrier frequency) are available to increase the third-harmonic rejection capabilities of the instrument (price each $20). The overall system frequency response is flat to 100 cps when used with a Brush oscillograph at carrier frequencies greater than 350 cps, and flat to 7 cps at lower carrier frequencies.

The characteristics of the BL-560 servoanalyzer are as follows: error-signal *amplifier:* carrier frequency—50 to 10,000 cps, sensitivity—0.5 millivolt per chart line, range—0.5 millivolt to 80 volts, input impedance—1 megohm (unbalanced or single-ended), gain—approximately 400, internal—20 millivolts gain calibrate signal; *reference amplifiers:* input—12 to 40 volts, impedance—1 megohm (unbalanced or single-ended); *demodulator:* frequency response with carrier frequency—50 to 350 cps—dc to 4 cps, plus or minus 1 db—dc to 7 cps, plus or minus 3 db.

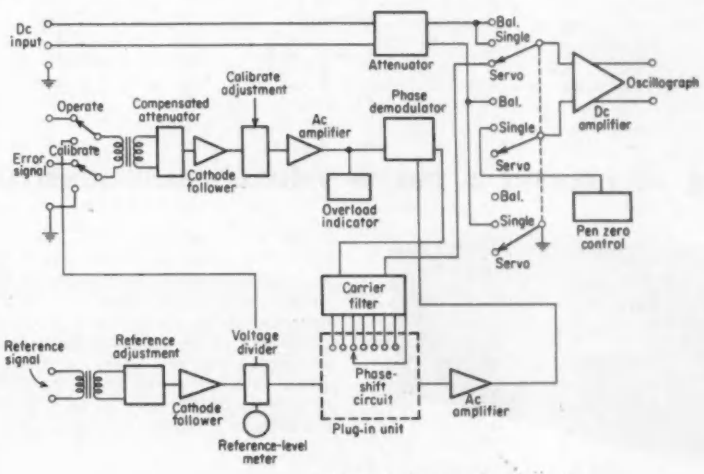


FIG. 4. Analyzer can handle both suppressed-carrier and dc inputs.

There are two demodulator filters, one for carrier frequencies below 350 cps (low filter) and one for frequencies above 350 cps (high filter). The high filter has a rise time of 0.01 sec and, when combined with a Brush oscillograph, is flat within plus or minus 1 db out to 100 cps. The low filter has a rise time of 0.1 sec and its output is flat within plus or minus 1 db to 4 cps and within plus or minus 3 db to 7 cps. The ac amplifier/demodulator combination produces a quadrature-rejection ratio of at least 100 to 1.

The Brush servoanalyzer will also handle a dc input. In this case the input passes through an attenuator to the dc amplifier, the same section that amplifies the filtered demodulator output and drives the pens. Amplifier characteristics are as follows: stability—one-fourth line of chart paper per hour with a total drift of less than half a line in eight hours; input impedance—1 megohm; maximum sensitivity—50 millivolts per chart line (1.0 volt full scale); range—single-ended 0.05 to 400 volts, balanced input 0.05 to 20 volts (maximum plus or minus 10 volts to ground on either terminal); calibration—1.0 volt signal from mercury cell; signal expansion—can shift signal up to plus or minus 200 lines from the center of the chart paper.

2. SANBORN SERVOMONITOR PREAMPLIFIER MODEL 150-1200

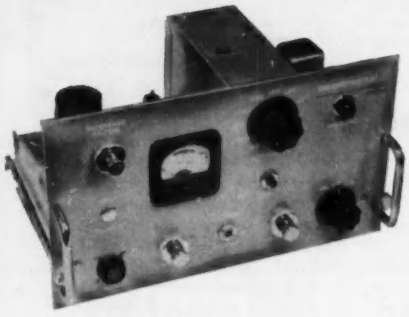


FIG. 5. Sanborn servomonitor preamplifier is designed as a plug-in unit to mate with other equipment.

The servomonitor preamplifier, Figure 5, is in the form of a plug-in front-end that mates with the Model 150-200/400 driver amplifier and power supply to form a complete oscillographic recording system. The output of the preamplifier is proportional to the envelope of a suppressed carrier signal.

Figure 6 shows the preamplifier block diagram. The suppressed-carrier input signal is amplified in an ac amplifier which has sufficient gain to give an overall recording sensitivity of 10 millivolts per cm to 10 volts per cm (in-phase component). The reference voltage drives an ac voltmeter to permit accurate level adjustment, and, in turn, provide a calibration signal for the recording system. The amplified signal and reference signal are combined in a phase-sensitive detector whose output is amplified and filtered. The filter has a 0.1-sec rise time when used with carrier frequencies below 200 cps, and a 0.01-sec rise time for carrier frequencies greater than 400 cps.

Good quadrature rejection is accomplished by careful design of the ac amplifier and demodulator to prevent phase shift (including a compensated stepped attenuator). An indicator shows when quadrature is present, assuring that the ac amplifier is operating in its linear range.

The overall characteristics of the servomonitor preamplifier with driver amplifier and recorder are: sensitivity—10 millivolts per cm to 10 volts per cm; carrier frequency range—60 to 10,000 cps; frequency response (to modulation)—low filter down 3 db at 3 cps, high filter down 3 db at 45 cps; input impedance—100,000 ohms; reference voltage—10 to 125 volts; internal calibration—20-millivolt signal; stability—less than 0.1 mm of baseline drift per hour (after warmup); quadrature rejection ratio—better than 100 to 1 for carrier frequencies to 5,000 cps, better than 30 to 1 for higher frequencies.

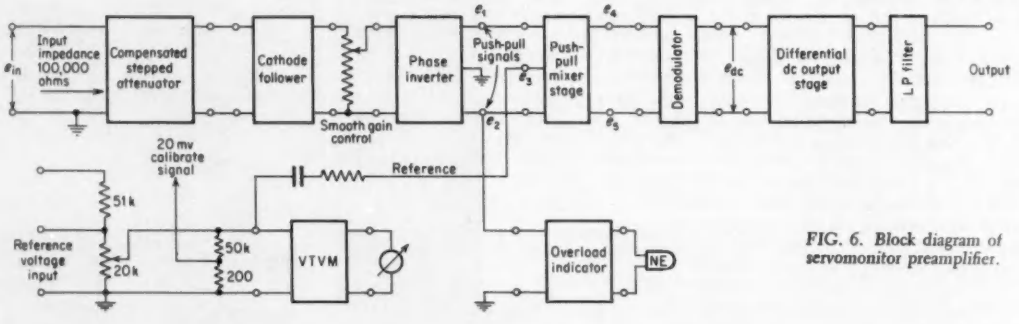


FIG. 6. Block diagram of servomonitor preamplifier.

3. BOONSHAFT & FUCHS VISUAL PHASE-SENSITIVE DETECTOR

FIG. 7. Visual phase-sensitive detector uses oscilloscope as a demodulator.

The visual phase-sensitive detector, Figure 7, is a new device for evaluating the transient and frequency response of control systems and components with suppressed-carrier signals. The detector is fed by the carrier reference signal and generates a narrow pulse accurately phased to occur at the peaks (positive and negative) of the carrier signal (within plus or minus 1 deg to 1,000 cps). These pulses are used to excite the z axis of an oscilloscope. The control system output is applied to the y axis of the scope, while the x axis is triggered by the step input for transient tests or is excited by the input signal for frequency response tests.

Lighting up the scope presentation of the suppressed carrier signal at the peaks of the carrier reference permits only the amplitude of the in-phase signal to ap-

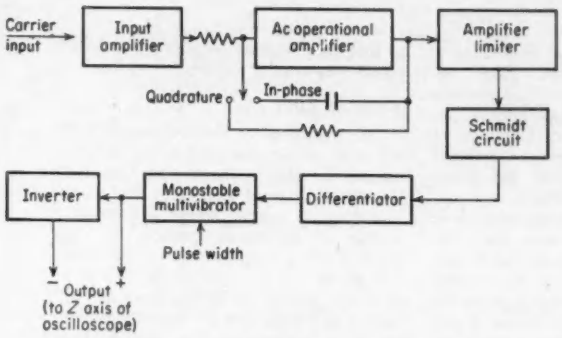


FIG. 9. Visual phase-sensitive detector generates pulses that energize the scope z axis.

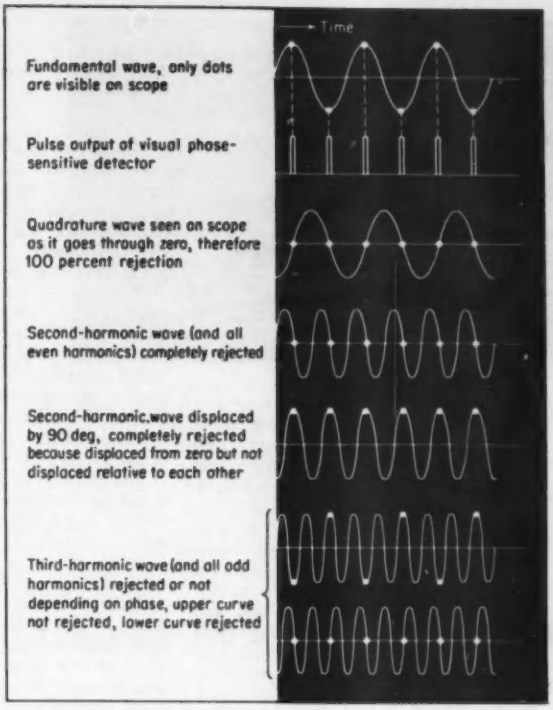

Time
Fundamental wave, only dots are visible on scope
Pulse output of visual phase-sensitive detector
Quadrature wave seen on scope as it goes through zero, therefore 100 percent rejection
Second-harmonic wave (and all even harmonics) completely rejected
Second-harmonic wave displaced by 90 deg, completely rejected because displaced from zero but not displaced relative to each other
Third-harmonic wave (and all odd harmonics) rejected or not depending on phase, upper curve not rejected, lower curve rejected

FIG. 8. Quadrature and harmonic rejection capabilities of visual phase-sensitive detector. Only the dots are visible on the scope.

pear on the scope. Quadrature rejection ratio exceeds 100 to 1 from 40 to 1,000 cps, and exceeds 50 to 1 to 4,000 cps. In addition, even harmonics of the carrier are rejected by at least 100 to 1. Odd harmonics of the carrier are either completely rejected or not rejected at all, depending on the relative phase. Figure 8 shows how quadrature and harmonic rejection is achieved when the scope presentation is visible only at the peaks of the carrier reference signal.

The visual phase-sensitive detector also provides a narrow pulse output that is accurately phased to coincide with the zero-axis crossings of the carrier reference signal. With these pulses used on the z axis of the oscilloscope, the in-phase component of control system output is rejected and the quadrature component becomes visible. This makes it possible to accurately null the quadrature component or to study the amplitude of this component against position, speed, etc.

Thus the visual detector makes an oscilloscope into a demodulator; and because the visual demodulation process does not introduce noise (as does the ordinary phase-sensitive detector), this demodulator does not require a filter. The true phase and the true time history of the control system output are presented, phase lag or time lag are not introduced, and accurate phase response as well as transient response can be seen.

Pulse generation at both the positive and negative peaks (or at both zero-axis crossovers) makes the amplitude measurement on the oscilloscope independent of the drift in zero position of the scope amplifiers. In fact, an ac amplifier can be used as long as it introduces negligible phase shift at the carrier frequency.

When used in conjunction with a scope that will permit the trace to be expanded beyond the size of the screen, this device will detect and allow evaluation of an output signal change that is only a fraction of the amplitude of the quadrature that is present. This can be very useful when making small amplitude tests at high frequencies.

Figure 9 shows the block diagram of the visual phase-sensitive detector. The reference signal is amplified by a high-input-impedance variable-gain amplifier, whose output is differentiated (phase shifted by plus 90 deg) by an ac operational amplifier. (When the output pulses are to coincide with the zero-axis crossover, this amplifier is switched from differentiation to amplification by a constant). Operational amplifier output is then amplified, limited, and used to switch a Schmidt circuit. The output of the Schmidt circuit is differentiated and applied to a monostable multivibrator, which provides the high-output, variable-width pulses that are applied to the z axis of the oscilloscope.

Note that the detector needs to be adjusted only when the carrier frequency or amplitude is changed. In no case is the control adjustment critical. By means of z-axis modulation to demodulate the carrier, and by increasing the intensity control on the scope, a complete picture of the test signal can always be seen. This makes sure there will be nothing unusual about the test results.

The visual phase-sensitive detector has the following characteristics: carrier frequency range—40 to 4,000 cps; carrier amplitude—5 to 200 volts; input impedance—1 megohm; pulse amplitude—50 volts, positive and negative; pulse width—2 to 140 microsec; source impedance—less than 5,000 ohms; quadrature rejection ratio—better than 100:1 to 1,000 cps; even-harmonic rejection—100 percent; odd-harmonic rejection—either none or 100 percent, depending on phase; phase and amplitude modulation distortion—none at all frequencies; transient-response distortion—no time distortion of the time-response envelope.

4. MUIRHEAD TRANSFER FUNCTION ANALYZER (WITH PHASEMETER D-729-B)

Very recently, Muirhead Instruments, Inc. augmented their phasemeter D-729-B with a two-phase low-frequency oscillator D-880-A and a tunable filter D-925-A to form a complete system for measuring the amplitude ratio and phase of feedback control systems. The instruments are shown in Figure 10; the phasemeter includes a separate power supply not shown here. The oscillator and filter were introduced too late for the complete system to be included in Part II.

Low-frequency oscillator

The two-phase low-frequency decade oscillator covers the frequency range from 0.01 cps to 11.2 kc. Operation is based on the solution of a second-order dif-

FIG. 10. Muirhead tunable filter (upper left), low-frequency phasemeter (lower left), and two-phase low-frequency decade oscillator.

ferential equation with damping, using two integrators and a sign changer. Two outputs, 90 deg apart, are taken from the integrator circuits. The unit emphasizes frequency accuracy, low harmonic content, and equality or proportionality of the two output levels.

Performance characteristics of the D-880-A oscillator are as follows: frequency accuracy—0.01 to 0.1 cps, plus or minus 2 percent; 0.1 to 11.2 cps, plus or minus 1 percent; 1.0 cps to 11.2 kc, plus or minus 0.2 percent; oscillator output—0-deg, 10 volts into 600 ohms; 90-deg, 10 volts into 10,000 ohms (constant to plus or minus 1 db over entire frequency range); harmonic content —0-deg output, 0.5 percent; 90-deg output, 1.5 percent; accuracy of 90-deg phase—1 deg above 1 cps, 3 deg at 0.01 cps; equality of two output levels—plus or minus 0.25 db. The unit is priced at $1,085.

The oscillator is used to excite the system under test. It is not necessary for the oscillator to feed the phasemeter, since the latter may operate to measure the relative phase and amplitude ratio of a block within the feedback control system loop.

Low-frequency phasemeter

The phasemeter D-729-B can measure control system response under sinusoidal test conditions from 0.25 cps to 10 kc. Meter operation is based on the fact that the vector sum or difference of two equal voltages is a function only of the phase angle between them.

Figure 11 shows a block diagram. Two identical amplifiers amplify the reference and unknown signals, which are read on the voltmeter and brought to the same level by the calibrated attenuators. The setting on the unknown-signal attenuator is a direct indication of unknown-signal amplitude. After adjustment, both signals are simultaneously applied to the adder whose output (arranged to be the vector difference of the two signals) is twice the set-level times the sine of one-half the phase angle between the reference and unknown signals. With the set-level made equal to 0.707 of full scale, the full-scale meter reading will represent 90-deg phase difference while the zero meter reading will represent zero-deg phase difference. Since meter displacement is proportional to sin $\theta/2$, and $\theta/2$ never exceeds 45 deg, the scale is almost linear.

The phasemeter provides a means for switching the reference phase to obtain correct meter readings when the phase angle is beyond the first quadrant. In addition, it makes it possible to determine the exact quadrant involved.

This instrument covers a frequency range of 0.25 to 10,000 cps. It measures phase angle to plus or minus 1 deg over most of this range, and amplitude to plus or minus 0.2 db for relative levels. Each channel's input impedance is 30 megohms, so that it can measure the output from points that are themselves at a high impedance. Inputs from 5 millivolts to 20 volts can be handled.

Highly distorted waveforms can be measured by making use of an external tunable selective amplifier in place of the meter amplifier. Up to 5 percent distortion will not reduce the above accuracies, and almost any level of distortion can be accommodated by using the external amplifier. Note that phase shift in the meter amplifier does not affect results, so that only accurate amplification of the signal frequency is required.

Tunable filter

The tunable filter D-925-A is a twin-*T* rejection circuit, designed to be directly inserted in the feedback circuit of the phasemeter output amplifier, and thus providing an overall acceptance characteristic at its tuned frequency. The filter covers a frequency range of from 0.5 cps to 10 kc in five ranges. It has a *Q* of 20, giving 26 db rejection of the second harmonic and 30 db rejection of the third harmonic. This permits the meter to be used with distorted waveforms, including demodulated signals.

The filter affects the gain accuracy of the phasemeter by less than 1 db, and mistuning of the filter is not a serious source of error because the filter is operating on the output amplifier after the two signals have been summed. Tuning is most critical when noise levels are high. The unit is priced at $315.

At small phase angles, the meter scale on the phasemeter can be expanded by reducing the attenuation in both channels; a full scale of plus or minus 6 deg is then readily obtained. Distortion in this instance is more critical, however, and a tuned external meter amplifier becomes necessary.

This method of phase and amplitude measurement is fast and accurate, but is limited for some control system measurements by not being able to go below 0.25 cps. The oscillator and phasemeter have broad application and should be considered for general laboratory use as well as for control system testing.

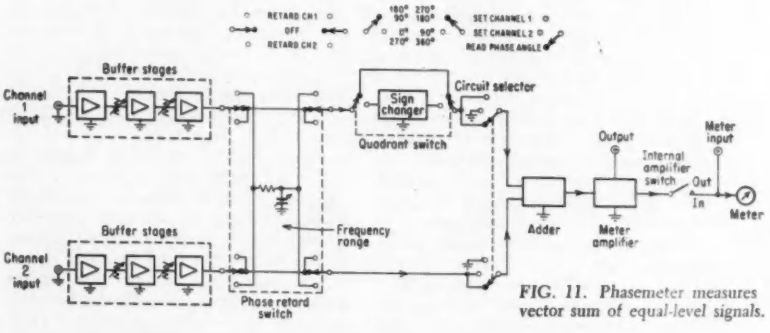


FIG. 11. Phasemeter measures vector sum of equal-level signals.

5. ADVANCE ELECTRONICS LAB. TYPE 405 PHASEMETER

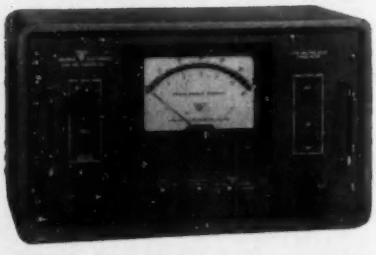


FIG. 12. This instrument requires no amplitude adjustment of either the reference or unknown signal.

This phasemeter, Figure 12, measures the phase angle between a reference and an unknown signal without adjusting for signal amplitude. In the block diagram of Figure 13, the reference and unknown signals are amplified by four stages of cathode-coupled limiters. These circuits provide a gain of 10,000 without altering the zero crossover point of the two signals. Then the two signals (essentially square waves) are applied to a coincident slicer circuit. As shown in Figure 14, this circuit yields a constant amplitude pulse whose width is directly proportional to the phase difference between the reference and the unknown signal. Averaging these pulses gives the dc input for the meter movement.

Full-scale phase reading can be set at 180, 90, 36, or 12 deg about either the

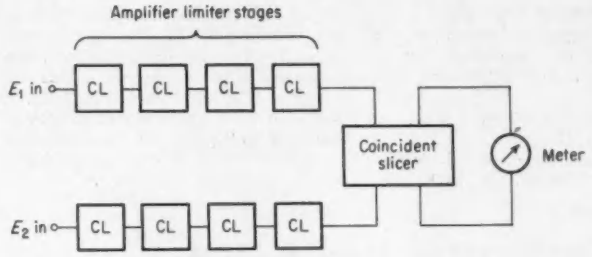


FIG. 13. Block diagram of Type 405 Advance Electronics Lab. phasemeter.

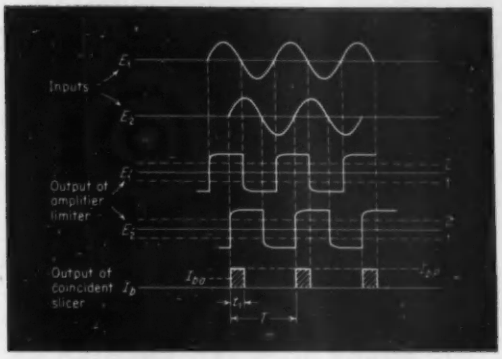


FIG. 14. Waveforms of various points in instrument; output pulses are averaged to provide meter input.

zero or 180-deg point. Note that phase measurement does not require adjustment for signal or reference amplitude, nor for frequency, and the zero point is not ambiguous, so that no adjustment is necessary here either. Phase lead or lag can be determined, and the instrument is self-checking.

Performance characteristics of the 405 phasemeter are as follows: frequency range—0.5 to 20,000 cps, input amplitude—0.5 to 70 volts, input impedance —6.8 megohm shunted by 20 mmf, accuracy—plus or minus 1 deg or 2 percent from 1 to 10,000 cps (error is much less than 1 deg when measuring small phase angles), drift (at small phase angles)—less than 0.001 deg for 10 hours.

6. ADVANCE ELECTRONICS LAB. ULTRA-LOW FREQUENCY PHASE-ANGLE COUNTER

For some time it has been recognized that digital counters can be used to accurately measure phase in the low-frequency range encountered in control system testing. Robert S. Melsheimer describes the procedure in detail in the paper, "A Digital Method for Precise Phase Measurement", available from Berkeley Div., Beckman Instruments, Inc. The general technique is as follows: The time interval between the zero crossover point of the reference signal and the zero crossover point of the shifted signal is measured. (The crossover with the same slope is selected for both signals.) The time interval, as shown in Figure 15, is compared with one period of the signal frequency, so that the phase lag in degrees is given by the ratio of the two counts times 360.

Extremely accurate phase measurement is possible because of the very high count rates available from modern counters. This accuracy, however, must still depend on the stability of the source oscillator for the test, as well as on the noise content of the reference and test signals. An exact definition of the effect of noise on measurement accuracy must be based on a careful evaluation of the particular instrument and of the noise characteristics. For example, harmonic content, phased so as not to modify the zero crossover of either signal, may not affect accuracy.

Figure 16 shows the ultra-low frequency phase-angle counter built by Advance Electronics Lab. for this application. Operation is based on a new circuit called the Advancetron, which generates a pulse at input signal crossover. It has a high degree of stability and repeatability at low frequencies.

In position 1, shown on the block diagram of Figure 17, the circuit counts 360 deg of the test frequency. The

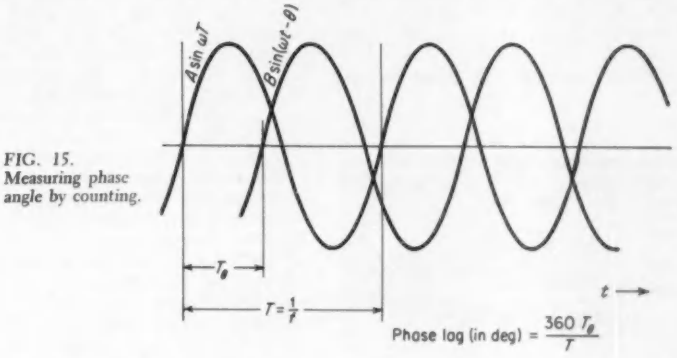


FIG. 15. Measuring phase angle by counting.

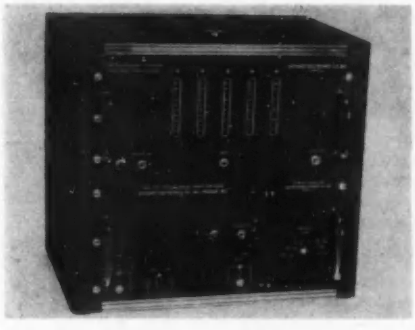


FIG. 16. Ultra-low-frequency phase angle counter.

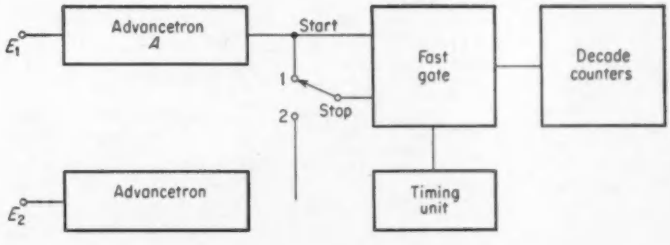


FIG. 17. Advancetrons in block diagram give pulse at zero crossover of input signal.

pulse from the Advancetron circuit opens the gate to permit pulses from the timing unit to enter the counter; the second pulse from the Advancetron closes the gate and stops the count. This count, N_1, represents 360 deg of the signal frequency. In position 2, Advancetron circuit *A* starts the count and Advancetron circuit *B* stops the count. This count, N_2, represents the phase angle between positive-going crossovers of the reference and the unknown signals. Then the phase angle θ, is given by

$$\theta = \frac{N_2}{N_1} 360 \text{ deg}$$

The frequency range of this instrument is from 0.00001 to 1,000 cps. Under 100 cps the maximum error is plus or minus 0.5 deg for input signals above 5 volts rms. Above 100 cps the maximum error is plus or minus 10 microsec. The input impedance is 2,400 ohms and the instrument will accept signals down to 0.5 volt rms (error increases to plus or minus 1 deg in the input signal range from 0.5 to 5 volts rms).

7. SOLARTRON TFA CARRIER CONVERTER TYPES JX541 & JX641

Although included with response-evaluation equipment, the Solartron Carrier Converter is actually a matching device that permits the use of the Solartron transfer function analyzer (Part II Item 6) with ac or suppressed-carrier systems. Figure 18 shows the unit.

The converter performs two functions (see parts A and B of Figure 19). First, the test signal generated by the O.S. 103A oscillator (Part I Item 5) is modulated to provide the suppressed-carrier input signal for the control system under test. And second, the converter demodulates the output signal (or the signal from any other point in the control system) to provide a dc signal for input to the response evaluation portion of the transfer function analyzer.

The converter's modulation section has the following characteristics: for Type JX541, the carrier frequencies are 400, 1,100, 1,600, and 2,400 cps; for Type JX641, they are 50, 60, 200, and 400 cps. Other carrier frequencies are available as special features. The modulator will accept a carrier reference signal from the control system of from 20 to 230 volts; the test signal from the O.S. 103A (or its equivalent) must be 20 volts rms, balanced. The output suppressed-carrier signal is up to 100 volts peak to peak, with a maximum power level of 400 milliwatts. In the standard unit, filtering of the modulator output to suppress harmonics limits the usable range of modulating frequencies to 10 percent of the carrier frequency.

The demodulating section of the converter has the following characteristics: With the Solartron resolved-components indicator (response evaluator) set for the 0.5-volt range, the carrier converter gives full scale at the indicator for as low a test signal from the control signal as 50 millivolts peak to peak. Maximum signal is 100 volts peak to peak. Considerable effort went into designing the demodulator filter to minimize phase lag at the signal frequency. The filter can even be switched out and the noise rejection characteristics of the resolved components indicator used to check the effect of the demodulator filters on the phase-lag measurement.

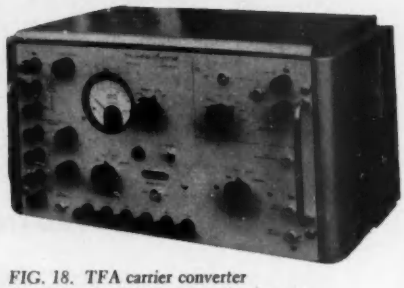


FIG. 18. TFA carrier converter permits using Solartron transfer function analyzer with suppressed-carrier systems.

Note that the instrument permits any combination of dc and suppressed-carrier control system input and output signals to be evaluated by the transfer-function analyzer. In the interest of complete test flexibility, Solartron offers its complete line of control-system test equipment in console form, as shown in Figure 20. This line includes the equipment discussed in these three articles, as well as other equipment offered by Solartron to facilitate control-system test work.

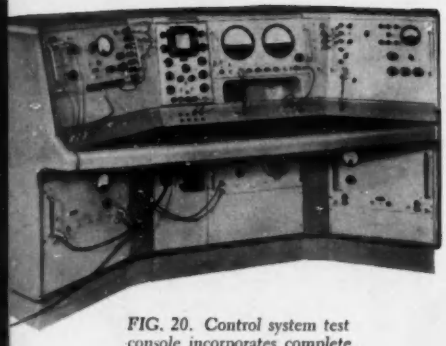


FIG. 20. Control system test console incorporates complete set of Solartron test equipment.

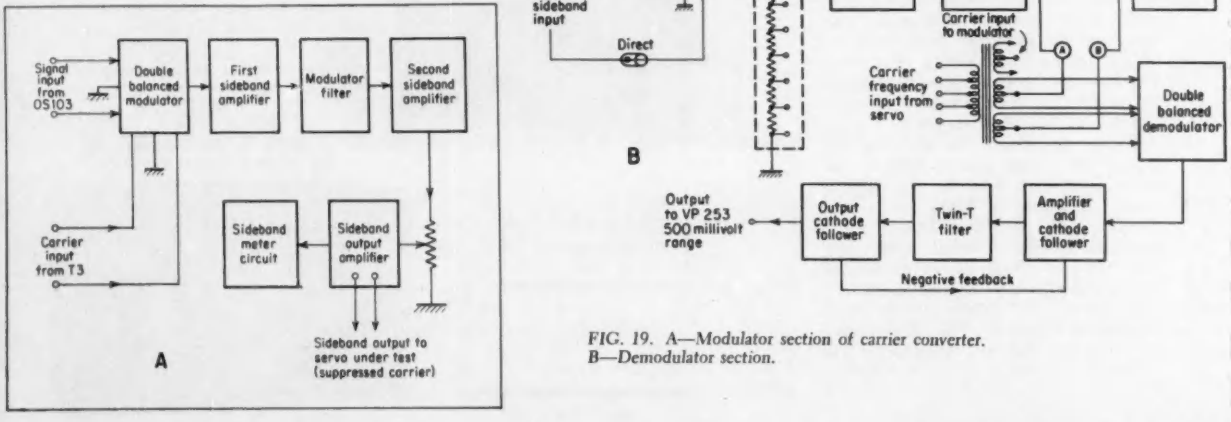
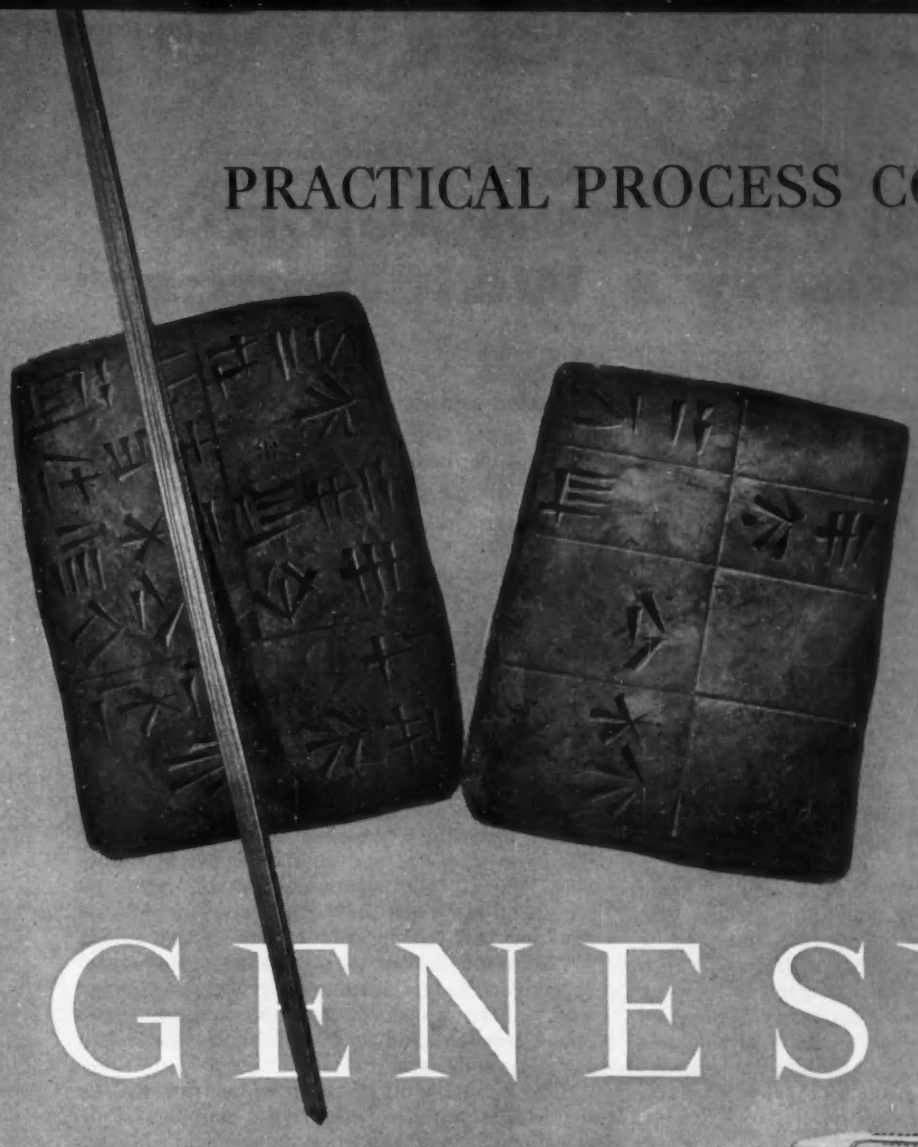


FIG. 19. A—Modulator section of carrier converter. B—Demodulator section.

CIRCLE 71 ON READER SERVICE CARD →

PRACTICAL PROCESS CONTROL



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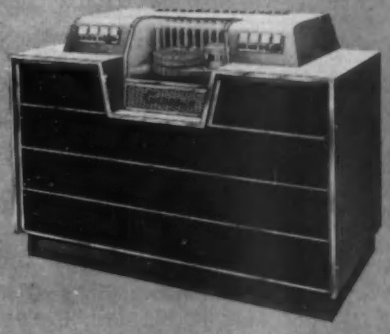

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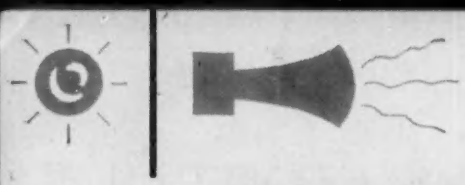


Alarm Annunciators: Industry's Watchdogs

Alarm annunciators keep an eye on processing and equipment conditions for the plant operator. The problem is to select the critical points that require monitoring and then pick the right construction, sequences, and type from a wide variety of commercially available annunciator systems. Here are the key factors in this selection process.

ARTHUR D. TAPLINGER, Multiplate Glass Corp.

Alarm annunciators warn an operator of abnormal conditions in process variables. Generally, one annunciator is used for each monitored variable and produces its own visual signal, identified by an associated inscription on a plate or window. The annunciator also can operate separate audible devices, such as bells and howlers, which may be common to all points.

Alarm annunciation starts at remotely located process variables requiring monitoring. Here there are sensing devices, like temperature and pressure detectors, which contain actuating contacts that open (or close) at a predetermined pressure or temperature. Sometimes the trouble contacts are contained in an indicator or recorder, as for analyzing and alarming on excessive CO_2. These contacts are spread throughout the plant and wired to alarm annunciators at the operator's control panel.

Annunciator functions

Commercially available annunciators have a variety of functional features. Many of them are common to all makers and others unique to a maker's product line. And the numerous combinations within the industry make for a wide range of annunciating systems.

Most annunciators contain contacts for operating an external audible device. Keeping the audible device separate gives the user complete flexibility of choice, allowing him to select, for instance, bells, horns, howlers, and sirens, and the pitch and decibel rating for each. Audible devices may be highly selective in direction of sound, or multidirectional. They may be located indoors on the control panel, or outdoors when properly weatherproofed and explosionproofed. Sometimes, the annunciator actuates a solenoid which in turn admits air or steam to high-energy whistles.

Essential to any annunciator—whether it is a simple or elaborate unit—is its acknowledge and silence function. By actuating a pushbutton switch, the operator silences the audible alarm and simultaneously sets the lights to an acknowledge condition. The exact status of the acknowledge lights depends on the sequence built into the annunciator. Table I gives a few of the sequencing possibilities and shows the status of visual and audible signals at various alarm stages. Some annunciators will return to process normal when the alarm clears; some lock in, requiring that the operator actuate a reset switch.

The visual display of process conditions again depends on the type of annunciator and the sequence used. Some sequences are: standard, dim and bright, two-light, and three-light. Each has its own peculiar advantages.

Most general applications of annunciators use the *standard* sequence, inherently the simplest. Individual process points function independently. Lights are out when conditions are *normal*; with an *abnormal* condition, they flash on and off, and are accompanied by an audible signal. When the operator presses the acknowledge switch, the audible signal is silenced and the flashing light becomes steady on. In some units, the flashing light is red—to further attract the operator's attention—and the steady light is white. Some units employ two white lights in parallel to guard against an unsuspected lamp burnout; the flashing and steady lights are both white.

The *dim and bright* sequence (dim for normal, bright for abnormal) is a modification of the standard sequence; but it can be employed in more complex annunciator systems. One may think of dim and bright not as a different (from standard) sequence, but as a different language of annunciation. The principal advantage claimed for this sequence is that under normal process conditions the lamps are always dimly lighted. This not only amounts to a continuous lamp test, but eliminates a test switch. A flasher is not required, although it is

sometimes used with a dim and bright sequence when other means of distinguishing incoming signals are not available.

Excessive illumination around the dim and bright annunciator sometimes makes it difficult to see whether lamps are burning dimly or not at all; this is particularly true with certain types of bullseye lenses. Also, when lamps age, the difference between bright and dim is not sufficiently distinct (though this may be overcome by using a variable transformer to boost voltage and increase light output—and the transformer also generates less heat than fixed, voltage-dropping resistors).

Some sequences use two lights, one for *normal* and another for *abnormal* condition. When an abnormal condition occurs, the abnormal light comes on flashing and the normal light goes off. After acknowledgement, the abnormal light is steady and remains on until process conditions return to normal. The lens covering each lamp—or the lamps themselves—can have different colors, such as green for normal and red for abnormal; this arrangement is widely used in individual bullseye annunciators. The *two-light* sequence, which is both positive and simple, is also available in multiple-panel cabinets and modular units with both bullseye and backlighted window design.

Three-light sequences have one normal light, one abnormal-high light, and one abnormal-low light. A typical application is in monitoring liquid levels where there is a high-level switch at one elevation and a low level switch at a lower one. The alarm contacts of these switches are connected to the annunciator as shown in the lower right corner of Figure 1A. Figure 1A depicts the normal condition, Figure 1B the abnormal-high or test-high condition, Figure 1C the abnormal-low or test-low condition, and Figure 1D the silence condition, which shuts off the howler and shunts the flasher to make the high or low light remain steady on.

Annunciators must be tested periodically to guarantee proper working order. Generally, a shift operator performs the test when he comes on duty, usually by depressing the *test* switch to cause all lamps to burn brightly. An audible test, sometimes accomplished by combining the *test* and *acknowledge* switches, simultaneously lights the lamps and sounds a horn. The *operational* test, particularly important in complex systems, simulates the sequence, checking all components in the annunciator.

The *sequential* feature enables the operator to distinguish the first alarm point from any subsequent ones even though abnormal conditions occur as close together as 35 millisec. Usually, the first alarm point is the only flashing light; after acknowledgement, it becomes a red light. For sequential operation, the important thing is to determine those monitored variables that are related by process considerations in such a way that if one exceeds its preset limits, the others are likely to follow suit. These points constitute a sequential group. Thus, in a sequential annunciator there may be many groups with as few as two points in a group, or all points may be in a single group.

Ringback goes one step further than acknowledge, since it calls for operator acknowledgement of the alarm signal as well as acknowledgement of *return-to-normal*. The *return-to-normal* signal is always visual and distinct from the alarm signal, see Table I. An optional audible signal may be used, but it, too, must be distinct from the alarm audible signal. With ringback, the operator knows immediately when the abnormal condition has been corrected. He does not have to continually reset the annunciator to see if the trouble has stopped, nor does he have to wait for the maintenance man to check in, after correcting the difficulty.

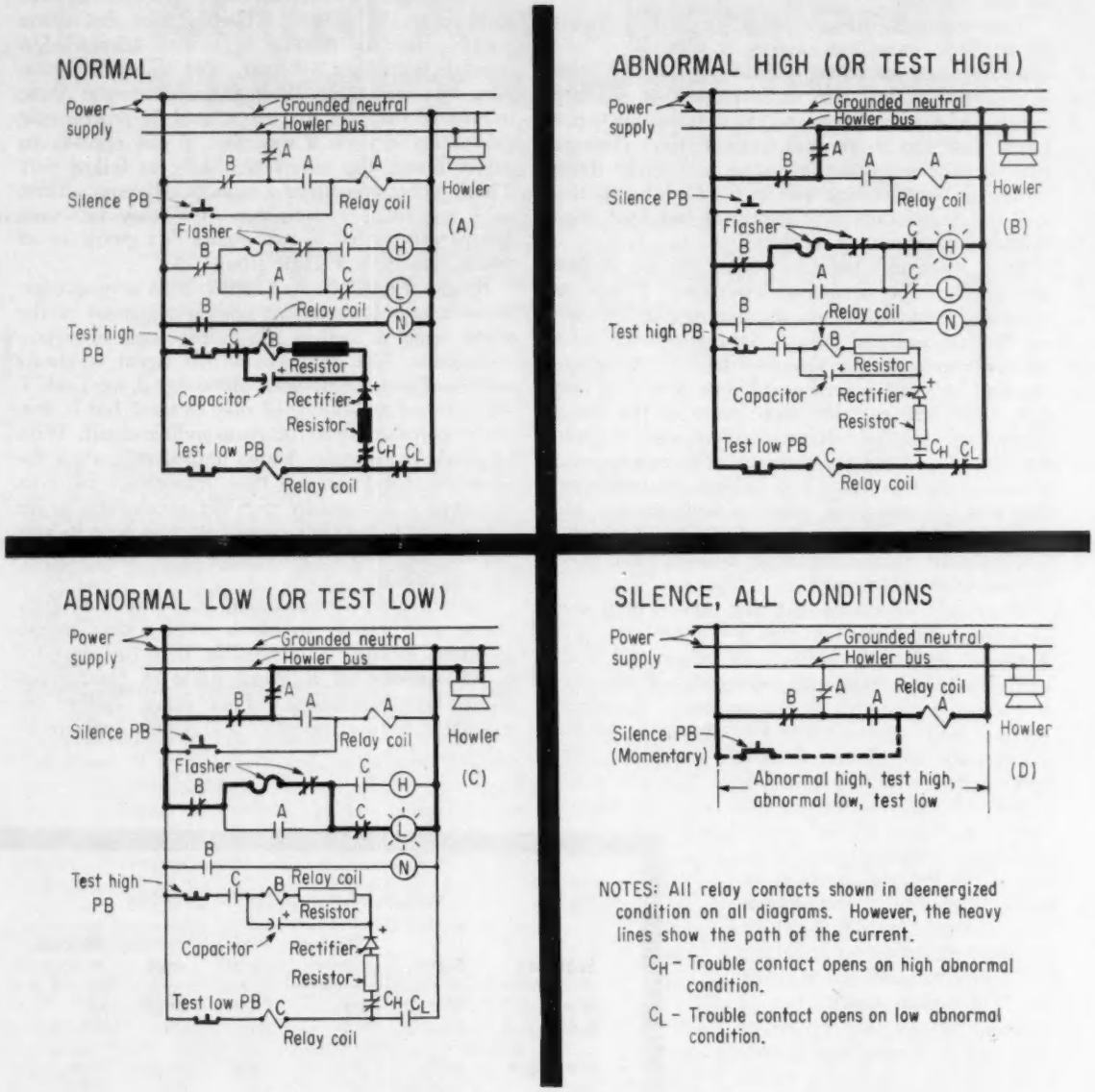
Lock-in spots a trouble-sign, no matter how transitory, and sounds an alarm until acknowledged. Without lock-in, it is possible that the operator could overlook an incipient cause of plant-equipment or process failure. *Time delay*, another annunciator feature, performs a function opposite to

Table I TYPICAL ANNUNCIATOR SEQUENCES

Sequence	Signal	*Process normal	Process alarm	Acknowledge	Returned to normal
Standard, backlighted	White	Off	Flash	Bright	Off
	Audible	Off	On	Off	Off
Dim-bright, flash	White	Dim	Flash	Bright	Dim
	Audible	Off	On	Off	Off
Dim-bright, bullseyes	Red	Dim	Bright	Bright	Dim
	White	Dim	Bright	Off	Dim
	Audible	Off	On	Off	Off
Dim flash, backlighted, ringback	White	Off	Bright flash	Bright	Dim flash
	Audible	Off	On	Off	On
Dim-bright, bullseye, ringback	Red	Dim	Bright	Bright	Dim
	White	Dim	Bright	Off	Bright
	1st aud	Off	On	Off	Off
	2nd aud	Off	Off	Off	On

*For ringback sequences, process normal is reestablished, following returned to normal, by actuating reset switch.

FIG. 1. **HOW A THREE-LIGHT ANNUNCIATOR WORKS**



lock-in; it lets the engineer ignore such unimportant conditions as momentary fluctuations of liquid level.

Most annunciators provide auxiliary contacts to permit the instrument engineer to use the alarm system for rough control or additional alarm indication. These contacts, either normally open or normally closed, can actuate an interposing relay so that a motor may be started or stopped.

Annunciators can be designed to fail safe, i.e., to indicate their own proper or improper functioning at all times. Basically, fail-safe protection is achieved by one or both relays being energized when the field trouble contacts are in the normal condition.

Basic annunciator types

In bullseye units, each light is separate and mounted behind a small circular lens of tinted glass. The usual colors are red, green, white, and amber. Backlighted units, however, have translucent plastic or glass windows with point-identification engraved in large letters. Different color lamps are located

behind the window. Backlighting has gained wide acceptance because it is easy to read at some distance.

Individual annunciators, each containing acknowledge and test switches, are usually the bullseye type, examples being *Visualarm* (Crouse-Hinds Co.) and *Unilarm* (Russell & Stoll Co.). Such units have been used in refineries for many years; they are adaptable to both panel and field mounting. [Miniature units (*Minilarm*, Russell & Stoll Co.) also lend themselves to graphic panels.]

Cabinet units for mounting annunciator groupings in flush-panel style are made by Panalarm (Panellit, Inc.), Scam Instrument Corp., Tigerman Engineering Co., and Electro-Mech Corp. Functions and construction differ, of course, from company to company, but in general they all use hermetically sealed, plug-in relays. Such cabinet units are ordinarily available with from four to 54 bullseye alarms, or from three to 48 backlighted alarms. Backlighted nameplates measure roughly 2¼ by 3 in.

Electro-Mech's U-200 Universalarm is shown in Figure 2. A common plug-in relay circuitry, for a choice of three sequences (automatic reset, lock-in, and ringback), can be intermixed in one cabinet and actuated from either normally-open or normally-closed trouble contacts; this is said to give extreme flexibility. Individual wiring at the terminal strip establishes the sequence pattern for a particular point.

Two sizes of backlighted nameplate models, ⅞ by 3 in. and 1 by 1½ in., help conserve panel space. The latter-size panel-mounted cabinet contains only the lights and nameplate, while a remote cabinet—perhaps mounted at the rear of the panel—contains the relays and associated circuitry.

Modular construction for flush panel mounting, available from Scam with backlighted nameplates, Figure 3, or dual bullseyes, is still another variation. The smallest module in the De-Line contains three points, and ranges in odd numbers up to 11. Such an annunciator system can be expanded vertically or horizontally by butting adjacent modules. A cabinet door is not required. Scam's Du-All line is similar in construction, offers two alarm points per light box, but cannot provide such features as *sequential* or *ringback*.

One annunciator innovation is using static switching elements in place of relays. The static annunciators perform the same functions as relay units, but are said to be more reliable by virtue of the absence of moving parts and contacts. However, static switching annunciators cost almost twice as much as their relay equivalent.

Panalarm's static-magnetic control annunciator, Figure 4, uses Westinghouse Cypak elements potted in epoxy resin and housed for plug-in connections. Scam's static switching annunciator, Scammit, uses semiconductors but no magnetic amplifiers. Lundell & Co. furnishes the Statalarm 110, using transistors and plug-in cards.

Designing an annunciator installation

When trouble contacts open (or close) for a particular variable they operate relays (or equivalent

FIG. 2. Electro-Mech's cabinet-mounted backlighted annunciator. Note plug-in removable from the front.

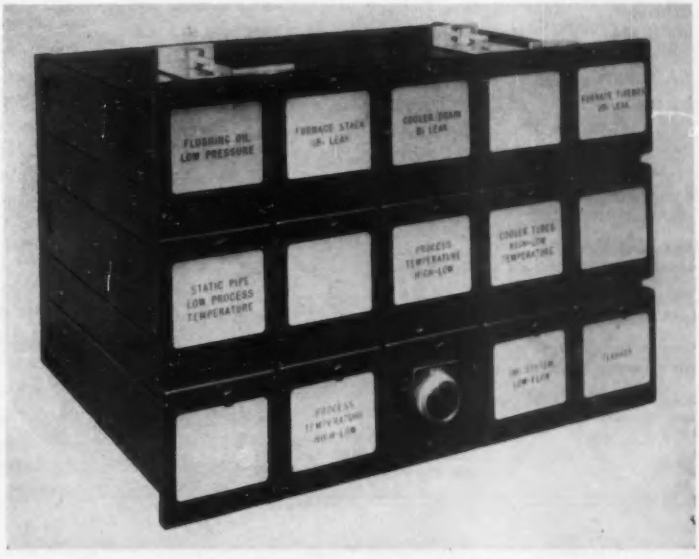


FIG. 3. Scam's modular annunciator. Note butting of adjacent modules, and provision for adding more points at later time.

FIG. 4. Panalarm's static magnetic annunciator.

static elements), lamps, flashers, etc., in the annunciator. The contacts carry or interrupt only the current in the holding coil of one relay. This current is about 0.06 amp at 120 vac, supplied from the annunciator. Inrush current may be 0.3 to 0.5 amp. Therefore, the minimum rating of the trouble contacts should be 0.5 amp. Such small current requirement leaves the engineer free to select pressure switches and the like whose contacts operate at small differentials between opening and closing. On the other hand, if the contacts cannot carry even this small current then interposing relays—with higher contact rating—must be installed.

Process needs and deployment of plant operators determine which alarm points will be in the control room and which will be in the plant. For example, compressor installations usually require annunciators at the compressor's local panel, but permit certain alarm points to be duplicated at the central control panel, which also contains most of the process and utility alarms.

Annunciators are located on the control panel to suit the operator's convenience. First priority in panel space goes to recorders, indicators, automatic-to-manual stations, selector switches, and other instrumentation that must be at hand instantly. Annunciators may be placed higher (less frequently, lower) than these instruments, but annunciator switches for acknowledge, test, and ringback must be within easy reach. If annunciators are located high up or the operator is some distance from the panel, consideration should be given to using full or extra-large-size backlighted nameplates for easy reading.

One way to save panel space and reduce wiring cost is to group alarm points associated with common process equipment into one zone, and connect one annunciator from the zone to the control room. Thus, for the compressor, there may be eight alarm points, each with its own local annunciator, but in the control room only one annunciator to tell the operator that the compressor is in trouble.

The number of spare points to be provided in an annunciator cabinet or panel depends on the number of active points specified in the original callout sheet. Providing spare points means leaving space and terminals for them; the relays can be plugged-in and terminals wired as the need arises. Spares may be from 10 to 100 percent of the active points; certain considerations are responsible for this percentage spread. For example, for new plants, particularly those using new processes, it may be advisable to provide anywhere from 40 to 100 percent spares. On the other hand, for plants using older processes on which some experience has been gained, 10 percent spares may be adequate. For small "packaged" process equipment, it may be permissable to eliminate spares altogether. There must be a reasonable compromise between initial cost and future needs.

Where several annunciating systems are employed in the same plant, an effort should be made to standardize on a single manufacturer and type, to reduce the inventory of spare parts and simplify routine maintenance.

Table II—APPROXIMATE ANNUNCIATOR COSTS

Type	Sequence	Annunciator cost per point, $	Installed cost per point, $
Cabinet or modules	Standard	55	62
	Dim-bright and flash	56	63
	Ringback with dim flash	61	68
	Sequential	61	68
4-unit groups exp-proof	Standard, bullseye	110	118
Exp-proof with separate relay box	Standard	150	164
Back-lighted cabinet with separate relay box	Standard	60	74
Single exp-proof unit with thermal flasher	Two-light, two-position	195	225
Single exp-proof unit with thermal flasher	Three-light, five-position (normal, high-low intermediate, high-low abnormal)	255	285

Annunciator costs

Table II lists approximate average costs of annunciators on a per-point basis. Except for single-point units, these costs are based on a 42-point annunciator system. Cost per point is less for more points, more for fewer points. The table shows, too, the variety of construction and sequences in available annunciators. The installed costs assume panel mounting, rigid conduit to panel bulkhead, and ringing out circuits within the control panel.

Use Shaded-Pole Motors for Those Not-Too-Critical Servo Systems

THE GIST: Properly designed, the reversible shaded-pole motor represents a low-cost substitute for some of the more conventional servo components. With an external supply across its shading coils, it becomes a two-phase motor. With its rotor driven externally, it serves as an ac tachometer generator. Reasonably good performance and a low price offset its somewhat higher power consumption in a number of commercial applications.

C. V. BULLEN, Barber-Coleman Co.

In a shaded-pole induction motor, the quadrature field required to start and run the motor is obtained by encircling part of each pole with a short-circuited winding or shading coil. In the familiar unidirectional form of the motor, each shading coil consists of a heavy copper ring around the leading end of the pole piece. Although voltage induced in these coils (by changes in the field winding flux) is but a fraction of a volt, the current produced may be 100 amps or more due to the negligible impedance of the copper. Thus magnetomotive force for establishing the shading flux may be in the neighborhood of 100 ampere-turns or more.

In the reversible shaded-pole motor, three sizes of which are shown in Figure 1, each pole contains two shading coils. Figure 2 illustrates the reversing operation. With switch S open, the motor will not run. When the switch is closed to the left, coils 1 and 4 are shorted and a clockwise rotation results. Similarly, closing the switch to the right produces a counterclockwise rotation.

Unlike the single-turn coils of the unidirectional motor, the shading coils of the reversible motor consist of many turns of fine wire. This, however, has no effect on the shading flux produced. Current in the winding will be considerably lower, but the number of ampere-turns will be the same. In practice, these shading windings are designed so that the voltages and currents can best be interrupted by sensitive contact devices.

Boosting the torque

When the motor is used for servo applications, shading coil power is supplied by an external source, usually an amplifier, connected across the terminals CW and CCW shown in Figure 2. Thus power is applied to all four shading coils connected in series. Phase of this voltage, relative to the phase of the field winding voltage, determines the direction of rotation. Strictly speaking, the motor is no longer a shaded-pole motor, but rather a two-phase induction motor, similar to other servo-type motors. With the connection mentioned, all four of the shading coils are energized simultaneously, compared to only two in the conventional connection. Furthermore, coil voltage is limited only by the allowable heating effect in the winding. As a result, the motor can produce considerably higher torque.

As an example, the size A motor of Figure 1 has a continuous-duty stall-torque rating of only 0.03 lb-in. when one pair of its shading coils is shorted. Supplying all four of its coils from an external source increases this stall-torque rating to 0.125 lb-in. without excessive heating.

The table below lists characteristics of three reversible shaded-pole motors and corresponding data for a typical small servomotor of the conventional two-phase type. The next to last line, comparing torque-to-inertia ratios, is a criterion often applied to servomotors. To establish a basis for comparison,

COMPARATIVE MOTOR CHARACTERISTICS

	Shaded-pole motors			Conventional
Motor type	Size A	Size B	Size C	2-φ motor
Reference winding input, watts	8.5	13	27	10
Control winding input, watts	9	10.6	31	3
Maximum no-load speed, rpm	3,100	3,000	3,270	1,550
Maximum stall torque, lb-in.	0.125	0.185	0.62	0.169
Rotor moment of inertia, lb-in.^{2}	0.0038	0.0057	0.0385	0.0081
Torque-to-inertia ratio	31.0	32.5	14.8	40.7
Price (lots of 100)	$5.76	$6.81	$24.02	$26.00

all torque and inertia values have been referred to a maximum speed of 3,000 rpm. On the basis of input power required and torque-to-inertia ratio, the shaded-pole motor suffers in comparison to the conventional type. However, the shaded-pole motor has a definite price advantage and in many applications provides all the performance required. Whether or not such a motor can be used for a particular application then depends exclusively on system requirements for accuracy, speed, stability, etc.

Figure 3 shows typical speed-torque characteristics for a size B motor with various voltages applied to the shading coils. Curves are for a standard motor with high-impedance shading coils, suitable for use with a vacuum-tube amplifier.

In operation, the motors produce maximum torque when field and shading currents are 90 deg apart. Since the field coil is more inductive than the shading coils, the optimum phase angle between the two applied voltages is less than 90 deg. For the size A and size B motors maximum stall torque is obtained with a 40-deg phase difference; for the size C motor this optimum angle is 60 deg. These values were used to obtain the torque-speed curves shown here.

Amplifier design

When the motor is driven by a vacuum-tube amplifier, the shading coils are usually excited in phase with the field, since the amplifier normally introduces very little phase shift. The insertion of phase-shifting networks could produce a torque increase of about 20 percent, but the amplifier gain would probably be reduced by at least this much.

The design of an amplifier for this application poses no serious problems. First the output stage is sized to deliver enough power to produce the desired torque. Then a voltage amplifier is selected with sufficient gain to drive the output stage with the available signal voltage. To eliminate the need for an impedance-matching transformer, the impedance of the shading coils can be initially matched to that of the output stage. The motor winding can then be coupled to the plate of the output tube through an electrolytic capacitor and the plate current fed through a reactor. Elimination of the output transformer provides higher efficiency at lower cost. Also, a single-ended rather than push-pull output stage eliminates the use of a phase inverter. To increase the output, two tubes can be paralleled, but this will require a lower shading coil impedance to preserve the match. Figure 4 illustrates a typical amplifier designed to get economical operation from a size A motor. Since plate voltage is supplied by a voltage doubler, there is no need for a high-voltage transformer. A small filament voltage transformer, however, will still be required. This amplifier is actually part of a servo system in which the motor reproduces the position of a manually-operated potentiometer. The motor drives a follow-up pot through a gear train to rebalance the bridge circuit.

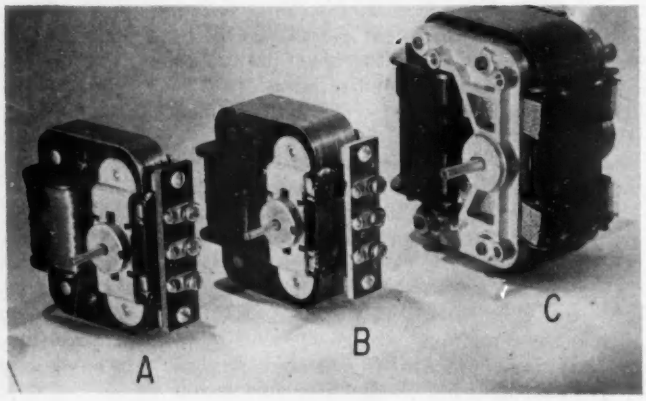


FIG. 1. Three sizes of reversible shaded-pole motors.

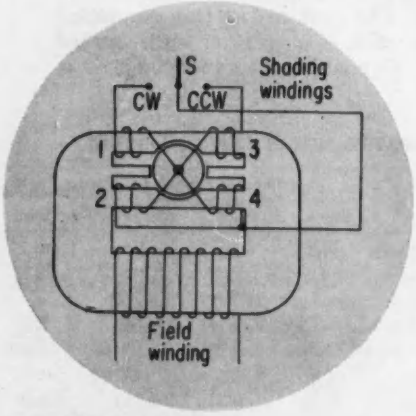


FIG. 2. Switch control for reversing rotation.

FIG. 3. Speed-torque curves for a size B motor with a 3,500-ohm shading coil impedance.

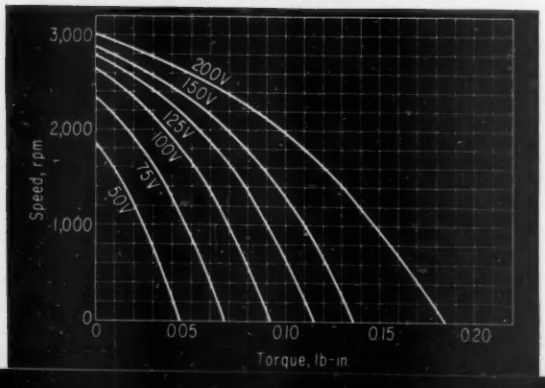


FIG. 5. Three possible chopper circuits for converting dc input signals.

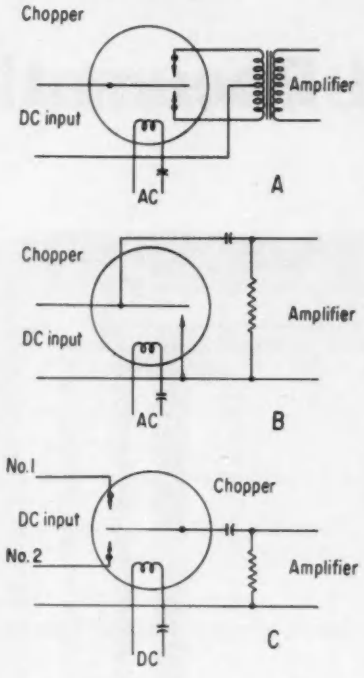
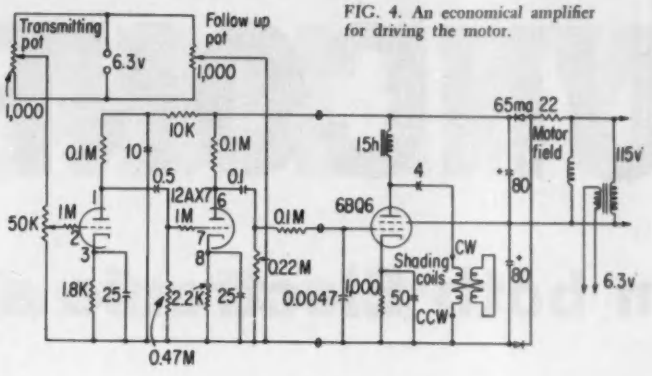


FIG. 4. An economical amplifier for driving the motor.



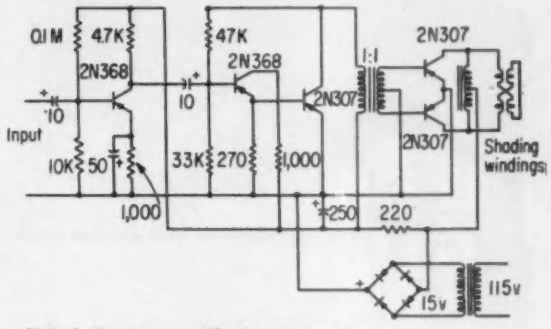


FIG. 6. Transistor amplifier for size A motor.

To control a B or C size motor, output of the above amplifier can be doubled by using a second 6BQ6 in parallel with the first. In this case, shading coil impedance would have to be half as great as for a single tube. Current capacity of the rectifier and coupling reactor would be doubled, and the cathode resistor reduced to half its previous value.

Where a dc signal must control the motor, some means must be provided to convert this to ac. Usually an inexpensive mechanical chopper will suffice. The circuits of Figure 5 show three ways in which a chopper may be connected. Circuit A uses an input transformer to provide some voltage gain and electrically isolate the input from ground. Circuit B eliminates the input transformer and circuit C compares two dc signals having a common ground.

Since a considerable phase lag exists between the voltage applied to the chopper coil and the contact closure, it becomes necessary to advance the phase of the chopper driving voltage. One simple technique consists of connecting the driving coil to its voltage source (usually the heater supply voltage of the amplifier) through a suitable capacitor as shown. The value of this capacitor should be such that the phase of the amplifier output signal produces maximum torque from the motor.

Figure 6 shows an easily constructed transistor amplifier suitable for driving a size A motor. Here a pair of low-cost power transistors operating in Class B provide a 10-watt output. In order that the center-tapped reactor be used in place of an output transformer, impedance of the motor shading coils should be about 32 ohms.

Current applications

Among the commercial applications in which these reversible shaded-pole motors have been used successfully as servo drives are: digital voltmeters, digital voltage ratio meters, millivolt recorders, aircraft simulators, an x-y recorder, a microviscometer, and a remote indicating tank-level gage.

More recently, the motors have been used as substitutes for ac tachometer-generators. In these applications rated ac voltage is applied to the main field winding. When the rotor is driven by some external means, a voltage proportional to speed is generated in the shading coils. Depending on the impedance of these coils, sensitivities of from 2 to 10 volts per 1,000 rpm are possible. The voltage-speed characteristic in these cases has been found to be fairly linear between 1,000 and 3,000 rpm.

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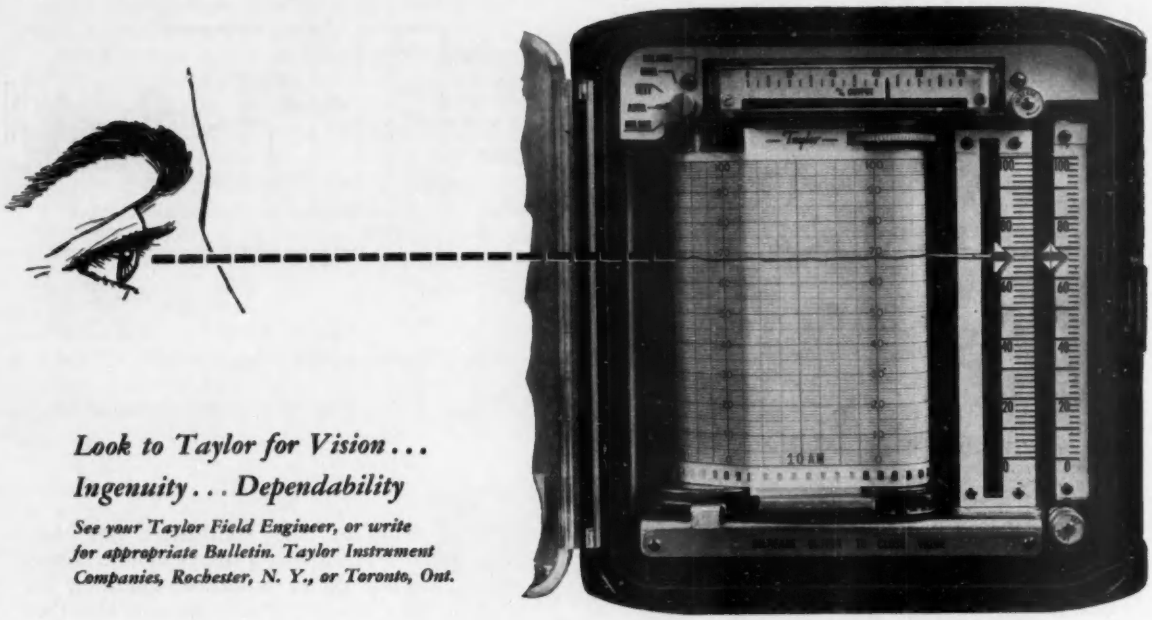

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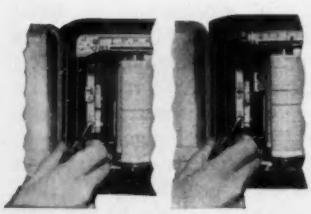

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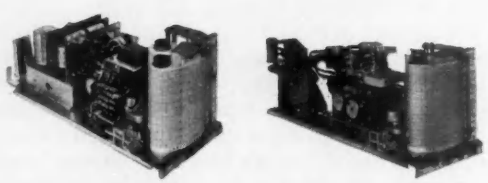

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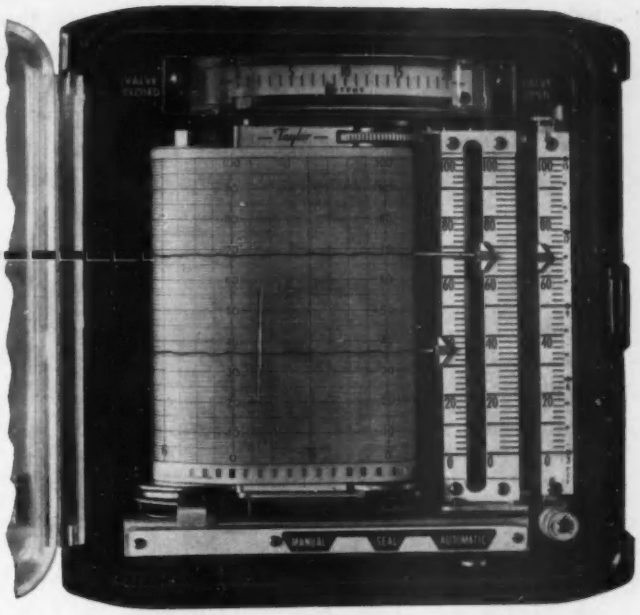
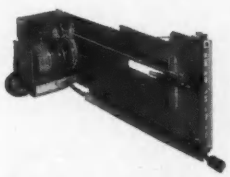
- **All these features** in a 6″ x 6″ cutout.

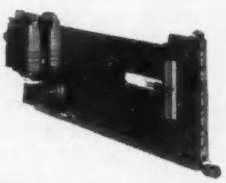
*Reg. U.S. Pat. Off.



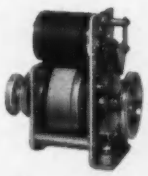
90J TRANSCOPE Pneumatic Recorder*

AC or DC Recorder and the 90J TRANSCOPE Pneumatic Recorder





3. Plug-in Set Point Transmitters, parallel to and exactly matching chart range, permit comparison without confusion and accurate adjustment of the control point. They can be removed for checking with only momentary interruption of record.



4. Powerful Servo Motors give more precise pen positioning than ever before. More accurate records. Unmatched threshold sensitivity. Unparalleled power permits use of process alarms, new inking system and elimination of flimsy linkage.

MEAN ACCURACY FIRST

CIRCLE 72 ON READER-SERVICE CARD

Where to Look for Trouble in a New EDP Installation

Putting electronic data processing to work is a bigger job than many companies bargain for. For one thing, it usually takes longer and costs more than is estimated. But experience with nearly a thousand machines of all sizes indicates that some of the pitfalls can be avoided. Here's what to look for when your company plans to convert to electronic data processing.

BEN CONWAY and D. E. WATTS
Price Waterhouse & Co.

A company installing a new electronic data processing system estimated a machine run would take 40 minutes, found in practice that it required two hours because tape records had grown 50 percent while tape utilization had slipped to 70 percent of the estimate. Another company planned to reduce its accounting force by 12 people when a computer was installed, discovered after the machine was working that 5 of the 12 were doing unmechanizeable work which had been overlook during the preliminary study. In a third installation, an expensive computer was delivered as the program for the first application was *almost ready*; six months later the program was *practically ready*; three months after that it was finally running.

These are just three out of the hundreds of unprofitable experiences suffered by organizations that have attempted to convert to electronic data processing. In each case, expected savings from EDP have failed to materialize. And EDP, in many places, has earned an unsavory reputation. Now, however, experience with nearly a thousand machines of all sizes indicates that many of the problems can be avoided if the right steps are taken at the right time.

Putting the EDP machinery to work is a four-phase program:

1) Preliminary studies to identify applications, select the equipment, and establish an implementation program.

2) Assembling and training a staff to carry out the implementation program.

3) Designing the system in complete detail and developing the programs.

4) Installation and conversion.

Each of these phases is costly and time consuming. Yet if each is done well, EDP equipment can pay off handsomely.

Preliminary studies

Frequently, the major difficulties with EDP installations stem from deficiencies in the preliminary studies; i.e., from overlooking, oversimplifying, or under estimating. Here are some typical examples:

- A feasibility study reported a job could be done in three computer runs. But the processing actually required 13 runs because the programs to do it in three runs were too big to fit in the memory.
- What appeared to be a straightforward IDP input procedure, in which magnetic tape was to be produced as a byproduct of document typing, turned out to be so restrictive, sensitive, and error-prone that it had to be abandoned in favor of typing, key punching, and verifying—at three times the estimated cost.
- Preliminary planning indicated that an existing card file (with 200,000 cards) could easily be converted to magnetic tape in 16 hours; but the cards, loaded with years of inaccuracies, X punches, and impossible code combinations, failed to pass the rigid clean-up tests of the conversion program. Conversion to tape actually took a major effort lasting over two months.

Probably the best way to prevent such disparities is to organize the preliminary study team with both experienced systems and computer specialists. Although such a team cannot guarantee the validity of the conclusions reached, it will avoid gross oversimplifications. If the right experience is not available in the company, it can be obtained by hiring qualified consultants—to conduct the study or to at least review the results before further action is taken.

Because the preliminary study always involves assumptions, estimates, and approximations, the early work is subject to modification as details are finalized. These uncertainties and their possible effect on the con-

Anticipating trouble starts with the preliminary study. Because such a study always involves assumptions, estimates and approximations, the early work is subject to continual review to determine how far and how fast the project should move. Next job is staffing the project. Better use of testing techniques is urged to get the right people on the EDP term, which should include computer specialists, system specialists and those in company operations being converted to electronic data processing. Then . . .

clusions reached should be considered in deciding how far and how fast to proceed.

No matter how thorough a preliminary study is, the overall economics and practicality of the EDP installation should be reevaluated from time to time during the system design phase. All conclusions are regarded as tentative until the details of the system have been worked out.

No firm commitments for machine delivery ought to be made until the system design and programming are well along. It's almost impossible, using preliminary studies alone, to predict exactly when a company will be ready to accept delivery of a machine.

Staffing the EDP project

Managers of successful EDP installations indicate that they had in their planning and programming groups a few outstanding people who carried a large part of the load and without whom the job could not have been done. It is almost essential to have at least a few people of this caliber, and a company can't have too many. Finding these people and getting them transferred to an EDP team is no small job. Management support is most important in getting the right people assigned to the project.

Once a capable staff has been assembled—and this can take months—the members have to be trained. Usually some people will know systems but not computers, others computers but not systems and still others have backgrounds in operating departments and know little or nothing about systems or computers.

Most companies have found that it takes a long time to develop in a diverse group of this kind the knowledge and skills needed to do the job. The time can be shortened by selecting the best people available, but beyond this there are no known shortcuts.

The fact that some individuals in a group of typical EDP draftees make remarkable progress and become mainstays of the project while others, seemingly as well-qualified, turn out to be virtually useless, suggests that testing and selection methods should be used more extensively. Unfortunately, many persons have been assigned to EDP projects by reason of their availability rather than their suitability for the job.

Some companies rely too heavily on manufacturers' promises of programming help. Manufacturers' programmers can provide some valuable assistance, particularly in the coding stage; but experience indicates that a company is better off to expect a manufacturer simply to deliver an operable machine approximately on schedule and then maintain it in working condition. It is unrealistic to expect the manufacturers' people, who are unfamiliar with the buying company and its problems, to assums any significant part of the system-design responsibility. There is no satisfactory substitute for a well-qualified staff within the buying company.

Designing and installing the system

In the design and installation phases both management support and company education are required. Too many companies undertake an electronics study on a closed-shop basis: most departments, sometimes including management, get no idea of what the EDP team is doing and/or what it hopes to do. As it pursues its unannounced investigation throughout the company, meeting apathy, suspicion, and opposition, rumor becomes rife and counter-proposals for other work-improvement programs are made and have to be evaluated, eating up valuable time.

In some cases, even where management had been sufficiently informed at the beginning of the program, the executives express dismay at the initial heavy investment and the continuing costs with little immediate return. This indicates that a continuing education process is necessary to keep management informed of the progress of the work. One way of doing this is to ap-

. . . system design is started. First, management support is required to get policy decisions made quickly. A prime objective of most programs is integration. Good programming is a complicated art that cannot be performed by amateurs. And the programming group needs strong direction and coordination to avoid duplication of effort. Controls are top priority to the accouutant for successful continuous operation.

point a top management electronics committee to which the data processing group can make regular reports.

System design

Such a top management committee is invaluable in avoiding another major source of trouble: getting policy decisions made. Electronic data processing programs cut across many departmental lines, and bring with them major organizational problems which the committee has to solve if the work is to proceed smoothly. The search into present methods may reveal inefficiencies and duplications. Such inefficiencies can often be removed only at top management levels. Similarly, the best method of processing under the new system may demand new policy decisions. Unless these decisions can be made quickly and with authority, the program stands a good chance of bogging down.

One of the prime objectives of most studies is integration. Unfortunately this has generally been understood to mean consolidation of records. For example, one utility combined a master file for meter information and one for customer information which necessarily included some, but not all, of the meter information. In each computer run involving the consolidated master file, so much surplus information passed through the computer system that the resultant loss of time far exceeded that required to set up the two master files.

The true concept of integration is making one unified system out of all the facets of a particular application —including all the clerical and peripheral work as well as the immediate data processing system. It is pointless to improve one portion of a system while leaving others alone. Extra inefficiencies can be added to the peripheral work in the name of improvements to the computer system. In some case, forms designed to facilitate input of information into the system actually doubled the work of some clerks prior to the input stage. Their jobs were not considered when the forms were designed.

Another area that has created problems is preparing a punched paper tape at the point of entry of data into the system for subsequent mechanical processing. The difficulties inherent in filing, reading, sorting, and guaranteeing the accuracy of such data are easily seen. But the difficulty of preparing data in the artificial word form imposed by most computer systems is not so clearly seen. Unless this fixed format is followed, the paper tape is useless as a computer input. Extra work and responsibilities are placed upon key punch clerks to record data in this unnatural form.

Converting punched cards to magnetic tape appears to be a simple tasks. But frequently information in the cards is found to be in error, or control punches appear where they have no right to be. It often proves more economical to start the conversion process from scratch rather than to attempt to use existing files.

Programming

Good programming is a highly complicated art that cannot be performed by amateurs. And automatic programming, while it reduces time and effort, demands even a higher order of knowledge. But whatever the emphasis is on—even the dog work of coding—the need for skill is still there.

Dr. Grace Hopper, one of the leaders in the automatic programming field, says that if the work of actual coding can be reduced from one year to one month by automatic coding techniques, the eleven months saved should be used for improving systems design and development, and not for advancing target dates.

The programming group needs strong direction and coordination to avoid duplication of effort. At one large company, for example, several hundred lines of programming were reduced to about 80 when it was realized that each coder had written separate routines for closely related problems without regard for what the others may have written. Each routine contained the same basic core of instructions, which had been repeated many times.

Associated with programming is the problem of efficient utilization of machine capacity. It is surprisingly

Final phase is installation of equipment. Scheduling is of key importance; parts should arrive in the proper order. Nothing is more demoralizing than the premature delivery of computer parts. One phrase of conversion should not be undertaken until the previous phase has been completely "debugged". Avoiding crash programs will get the computer working to the satisfaction of all segments of the company.

easy to exceed computer capacity on all but the most simple programs; and the use of tapes or discs for storing extra program steps, to be called for as required, is time consuming and unwieldy. If the operations are at all complex and have many exceptions, the only answer is to cut down the all-inclusiveness of each computer run. Each run then becomes complete within the limitations of the computer memory capacity; exceptions are placed aside and processed in one or more subsequent runs instead of calling in various program instructions during the regular routine.

The use of the "calling-in" technique, known as "overlay", raised time requirements about four times in one installation. The company finally had to reduce the number of processes attempted in any given run.

From the accountant's viewpoint, controls rate top priority. As the work proceeds automatically within the computing system, it is necessary to impose internal controls to assure that input data is correct, that the computer system does not malfunction, and that the program does what it purports to do. But what constitutes adequate controls is questionable. At the start, the best idea is to use only as much control as is incorporated into the present system. Undercontrolling can be disastrous, but from a time viewpoint, so can overcontrolling.

Limit controls

No controls should be added unless they are absolutely unavaoidable. In one installation, every item in a master file, whether it was active or inactive, was checked in each pass through the computer to see that its format was correct. The time required to process the master file when this unnecessary control had been removed was reduced to one-eighth of the original time.

The accountant also wants to document a program fully, for without such documentation, an opinion on the accuracy and validity of the problem is incomplete. But this complete documentation is just as important to the data processing group and the company. It includes block diagrams, broad and detailed flow charts, and recording of the actual coded program with an instruction-by-instruction explanation. Even with thorough documentation it is difficult for one programmer to follow another's program. Without detail explanation, checking of programs becomes very difficult, modifications to the program become almost impossible—and the company is vulnerable to personnel turnover.

Installing the System

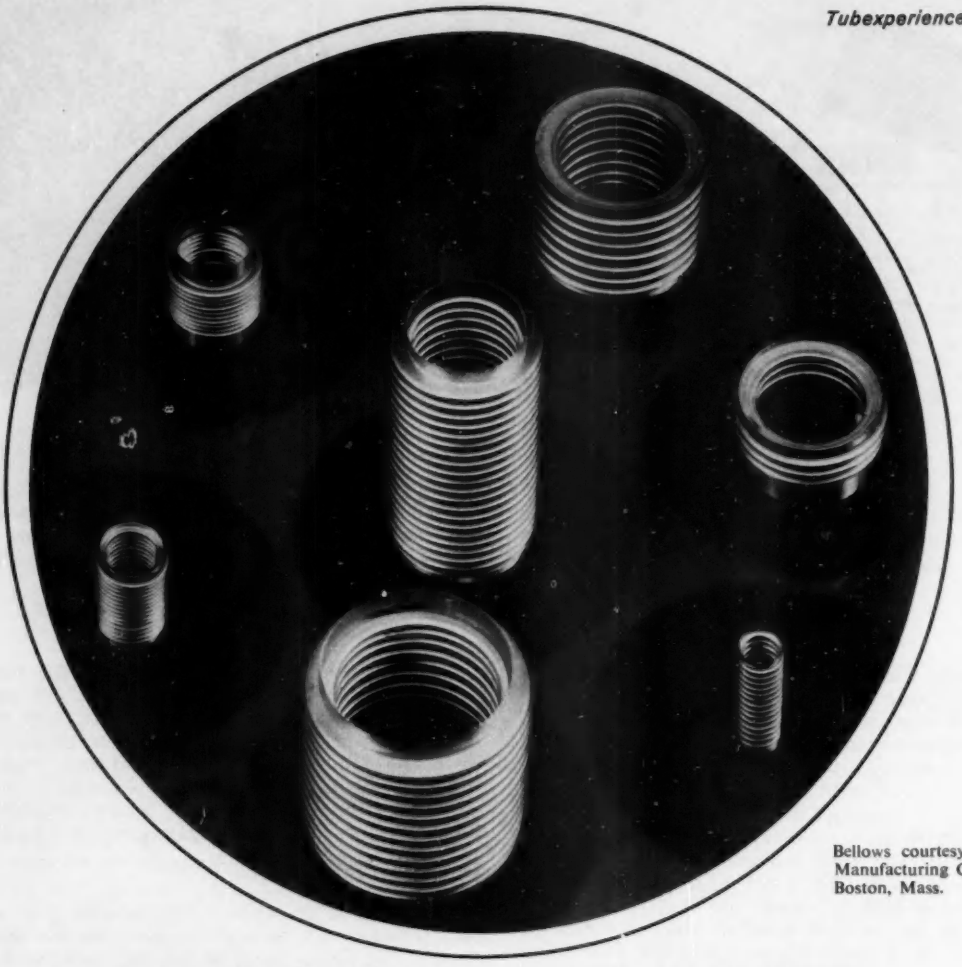
Scheduling is of key importance. The great cost of a computer system generally precludes the use of standby equipment, so that all the work must be channeled through one machine. Priorities, based on policy decisions which the electronics committee, previously mentioned, should be able to make, must be established for processing. Breakdown presents very special problems: the manufacturer has to guarantee adequate maintenance and alternative facilities.

Each portion of the program has to be very carefully checked out by running it in parallel with the existing procedures and comparing results. Program errors are then corrected, either in a patchwork fashion, or by rewriting the entire program. One phase of conversion to the electronics program should not be undertaken until the previous phase has been "debugged".

No program should be put through a computer unless a programmer or someone who thoroughly understands the program is present. A logical system for locating program errors should be designed for the console operator.

Tremendous problems are created when the equipment is delivered before the company is fully ready for it. Everything is put on a crash basis, which brings with it inherent inefficiencies. The company should establish a reasonable program for delivery, but not hesitate to delay delivery if circumstances demand it. Nothing can be more demoralizing to management or the electronics group than to have a computing system delivered before it can be used.

Tubexperience in action



Bellows courtesy Clifford Manufacturing Company, Boston, Mass.

750,000 flexures without failure

—a common performance record for bellows formed from Superior Thin-Wall Tubing

Bellows, more sensitive than spirals and better adapted to accurate measurement of pressure and vacuum, or absolute pressure in the low and intermediate range, must withstand thousands of flexures without failure. The tubing from which they are made must be highly uniform in physical and mechanical properties and must have the invariably smooth surfaces that contribute so much to good fatigue life. It must be extremely ductile—forming pressures run as high as 5000 psi. Brazing operations used to fasten it to another assembly may subject it to temperatures up to 1800°F. It must have excellent corrosion resistant characteristics. And it must be free of carburization, dents and pickups that lead to premature fatigue failure of the bellows in service.

Thin-wall tubing of this quality—usually under .010 in. max. wall thickness and held to a tolerance spread of only one-thousandth inch—requires the skills and facilities of tubing specialists. Superior maintains production standards fully in keeping, employs special handling procedures, uses special controlled-atmosphere furnaces to provide the uniformly annealed tubing demanded. Superior tubing is produced in a wide range of analyses, in both Seamless and WELDRAWN® types, and to specified IDs, ODs and wall thicknesses.

Bellows tubing is just one of many types supplied by Superior. Available are more than 120 analyses, in a wide range of sizes, and meeting almost any requirement. For a good glimpse of the field covered by Superior, send for Bulletin 41. Superior Tube Company, 2026 Germantown Ave., Norristown, Pa.

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All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

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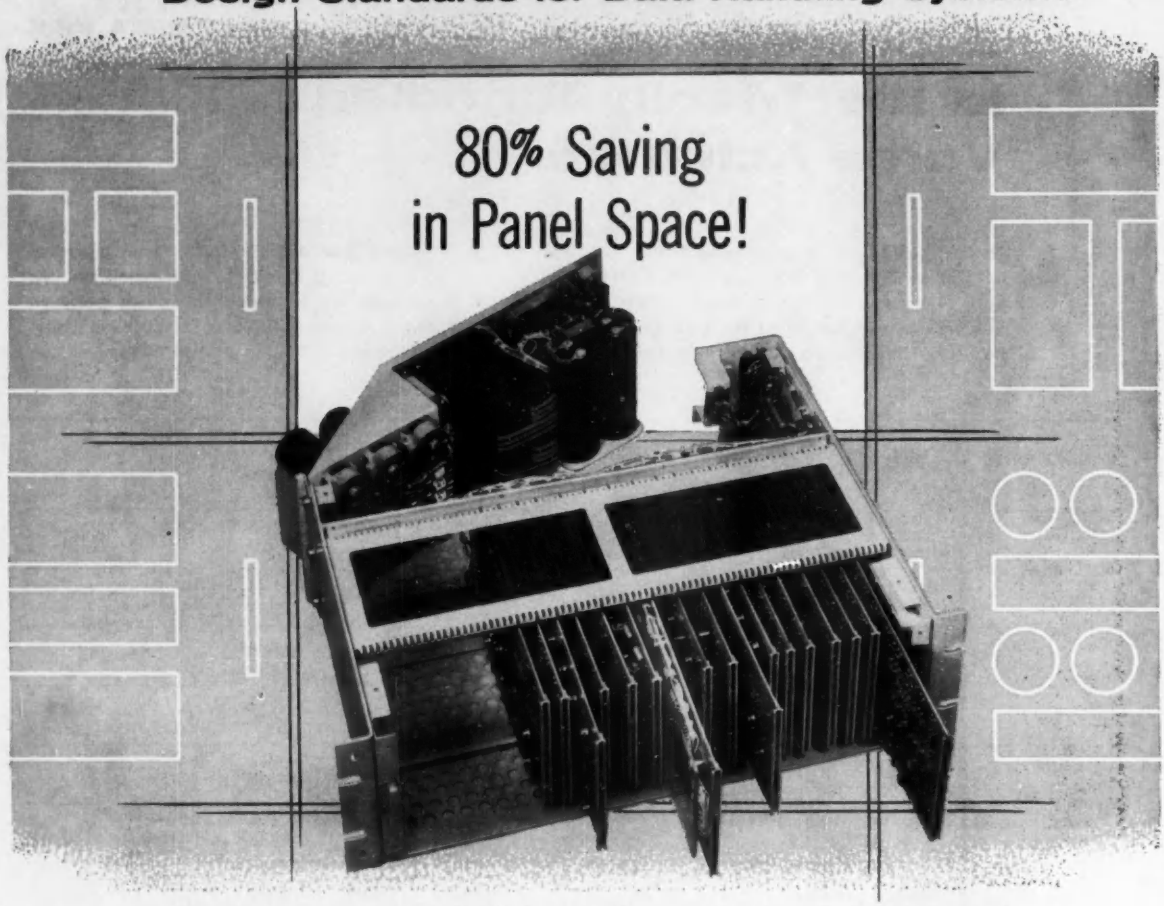
A Short Guide to Electrically-Signaled Valve Actuators

The increasing use of electronic control systems in process instrumentation (see CtE Special Report, November 1958) has directed considerable attention to the hardware for such systems. Of particular interest are the valve actuators which, by one means or another, convert an electrical input signal into a particular valve position. As a design aid, the following table lists performance characteristics and prices for 18 electrically-signaled actuators on the market today.

MANUFACTURER	MODEL NUMBER	TYPE	NO-LOAD STEM SPEED, IN./SEC	MAXIMUM STROKE, INCHES	STALLED THRUST, POUNDS	LINEARITY, PERCENT WITHIN	INPUT SIGNAL	FEEDBACK USED	FREQUENCY RESPONSE, CPS	UNIT PRICE, DOLLARS
THE ANNIN CO.	20,000	ELECTRO-HYDRAULIC	12.5	0.625	4,140	1.0	1-5 OR 10-50 ma dc	POTENTIO-METER	40	1,600
	30,060A	ELECTRO-PNEUMATIC	0.58	0.75	3,400	2.0		RATE SPRING	1.0	270
CONOFLOW CORP.	LD-62XD	ELECTRO-MECHANICAL	0.1	2.0	600	1.0	1-5 ma dc	SPRING	—	495
	B-50XE	ELECTRO-PNEUMATIC	1.0	4.0	3,000	1.0		FORCE BALANCE	—	(NOTE E)
FISHER GOVERNOR CO.	340	ELECTRO-HYDRAULIC	0.1	1.5	600	2.0	1-5, 0.3-5, 10-50 ma dc	FORCE BALANCE	0.44 (NOTE A)	400
	350	ELECTRO-HYDRAULIC	0.37	3.0	2,000	2.0		FORCE BALANCE	0.8 (NOTE A)	450
GENERAL CONTROLS CO.	HYDRA-MOTOR	ELECTRO-HYDRAULIC	0.07	5.0	6,300	1.0	0-135 OHMS	POTENTIO-METER	—	100-1,000
	TORK-MASTER	ELECTRO-MECHANICAL	0.33	NO LIMIT	4,500 FT-LBS	3.0	0-135 OHMS	POTENTIO-METER	—	500-3,000
	DM-4	ELECTRO-MECHANICAL	1.0 rpm	180 DEG	20 FT-LBS	3.0	0-135 OHMS	POTENTIO-METER	—	50-100
GPE CONTROLS, INC.	697	ELECTRO-HYDRAULIC	0.12	1.5	220	2.0	1-5, 4-20, 10-50 ma	FORCE BALANCE	0.1	260
	698	ELECTRO-HYDRAULIC	0.1	1.5	500	2.0		FORCE BALANCE	0.1	330
	684-25	ELECTRO-HYDRAULIC	0.5	2.0	1,000	2.0		FORCE BALANCE	0.7	450
	684-50	ELECTRO-HYDRAULIC	0.7	2.0	1,500	2.0		FORCE BALANCE	0.7	500
MANNING, MAXWELL & MOORE, INC.	4-181RL	ELECTRO-HYDRAULIC	0.3	4.0	1,250	0.5	1-5 ma	FORCE BALANCE	1.0	450
	4-181RH	ELECTRO-HYDRAULIC	0.16	4.0	3,250	0.5		FORCE BALANCE	1.0	600
MASON-NEILAN DIV., WORTHINGTON CORP.	250	ELECTRO-HYDRAULIC	0.3	4.0	3,500	3.0	(NOTE D)	DIFF X-FORMER	1.0 (NOTE B)	1,500
NORWOOD CONTROLS	1101	ELECTRO-MECHANICAL	0.15	2.0	1,000	2.0	1-5 ma	POTENTIO-METER	1.5 (NOTE C)	495
THE SWARTWOUT CO.	T2D	ELECTRO-VAPOR	0.1	1.5	300	—	1-5 ma	FORCE BALANCE	—	325

NOTES: A—Response at 90 deg phase shift, full stroke
B—Depends on input; flat to approximately 1.0 cps
C—Response given for 3 percent of stroke
D—Operates on any commercially-available input
E—Price to be available very soon

Magnetic Core Buffer Memory Sets New Design Standards for Data Handling Systems



Requires only 5¼" of Space in a 19" Rack

From General Ceramics—Four new magnetic core buffer memories that are setting new design standards among data handling system designers requiring increased efficiency in smaller physical packages.

Now available in either random access or sequential designs:

144 M4A — 144 characters in 9x16 array with a word length of four bits.
144 M8A — 144 characters in 9x16 array with a word length of eight bits.
512 M8A — 144 characters in 16x32 array with a word length of eight bits.
1024 M8A—1024 characters in 32x32 array with a word length of eight bits.

Design Features Include—

1. **SPACE-SAVING**—Require only 5¼" of standard rack space . . . permit smaller overall system design.
2. **VARIABLE CHARACTER AND BIT LENGTHS**—Unique design of driver circuit permits circuitry of existing data handling system to be enlarged without costly redesign.
3. **HIGHER OPERATING TEMPERATURE RANGE**—Contributes to miniaturized system design because memory functions satisfactorily under higher ambient temperature conditions.
4. **EASE OF MAINTENANCE**—All components are within easy reach. All circuits are on plug-in cards except power supply which is hinged across the back; swings out for easy accessibility.
5. **EXTRA FEATURES**—All units are equipped with an electronic clear and output register at no extra cost.

Complete detailed technical information will be supplied promptly on request. Please address inquiries to Dept. CE.

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Applied Logics Division
GENERAL CERAMICS CORPORATION
KEASBEY, NEW JERSEY, U.S.A.

 CIRCLE 74 ON READER-SERVICE CARD

Mechanical Feedback Improves Hydraulic Servovalves

Making hydraulic and hydromechanical feedback elements integral parts of electrohydraulic servovalves produces a family of control components with a wide range of dynamic characteristics. In a system, these components improve performance and simplify construction.

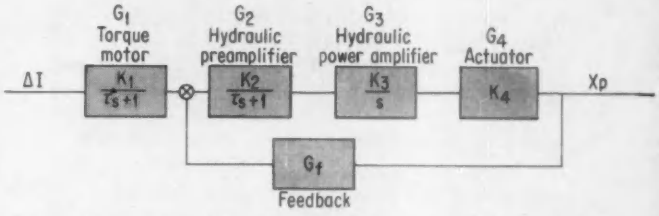


FIG. 1. Block diagram of integrated servovalve-actuator-feedback control system.

JOHN W. BLANTON and SAMUEL A. GRAY
Hydraulic Research & Mfg. Co.

Figure 1 diagrams the manner in which feedback ought to be applied to electrohydraulic servovalve-actuator systems. The transfer functions shown are typical for a flapper-nozzle type valve. The closed-loop transfer function for such a system is

$$\frac{X_p}{\Delta I} = G_1 \frac{G_2 G_3 G_4}{1 + G_2 G_3 G_4 G_f} \qquad (1)$$

Position servo systems

The electrohydraulic servovalve (G_1, G_2, and G_3 in Figure 1) is often used with position feedback from a separate actuator to form a position servo system. The feedback is commonly electromechanical, using electric summation of the signal from a potentiometer on the actuator output with the *input* signal to the torque motor. Though not as common, the all-mechanical feedback diagrammed in Figure 1 is better because the actuator will return to a preselected null in case of an electrical failure. Such a "fail-safe" characteristic can be extremely important. It could easily avert a tragedy, for example, that could be caused by position controls on the control surfaces of an aircraft jamming hardover on loss of an input signal.

Mechanical position feedback can be applied as shown in Figure 2, where $G_f = K_f$. The overall closed-loop transfer function in this case becomes

$$\frac{X_p}{\Delta I} = \frac{K_1/K_f}{(\tau_1 s + 1)\left(\frac{s^2}{\omega_n^2} + 2\zeta\omega_n s + 1\right)} \qquad (2)$$

where:

$$\zeta = \frac{1}{2}\sqrt{\frac{1}{K_2 K_3 K_4 K_f}} \qquad \omega_n = \sqrt{\frac{K_2 K_3 K_4 K_f}{\tau_3}}$$

In an integrated servovalve-actuator-feedback system, the feedback link and spring can be kept short and light and thus insensitive to vibration and acceleration. The dynamic performance of such systems is comparable to or better than electronic feedback systems with similar system gains.

The position servo system of Figure 2 uses the common flow control servovalve, in which displacement of the flapper from null (spool centered) position causes an increased flow through one nozzle (and decreased flow through the other). Increased nozzle flow causes increased pressure drop through the fixed orifice and vice versa, and thus, a pressure differential across the ends of the spool. The spool moves until the differential force due to the centering springs balances the force due to the differential pressure times the area of one end of the spool. The spool deflection is linearly proportional to differential current in the torque motor coils, causing a proportional oil flow rate to the actuator.

Rate servo with hydromechanical feedback

Applying rate feedback around a servovalve and an actuator is a different problem. The mechanical solution in this case is to use a piston with a calibrated fixed orifice in series with the load flow to drive the feedback spring instead of the simple link (see Figure 3). The feedback function G_f is

$$G_f = K_f \frac{s}{\tau s + 1} \qquad (3)$$

and the overall closed-loop response is

$$\frac{X_p}{\Delta I} = \frac{\frac{K_1(\tau_f s + 1)}{K_f}}{\left[\frac{\tau_2 \tau_f s^2}{K_2 K_3 K_4 K_f} + \frac{(\tau_2 + \tau_f) s}{K_2 K_3 K_4 K_f} + 1\right](\tau_1 s + 1)} \qquad (4)$$

The spring-centered piston with the by-pass orifice is the hydraulic equivalent of an electrical high-pass

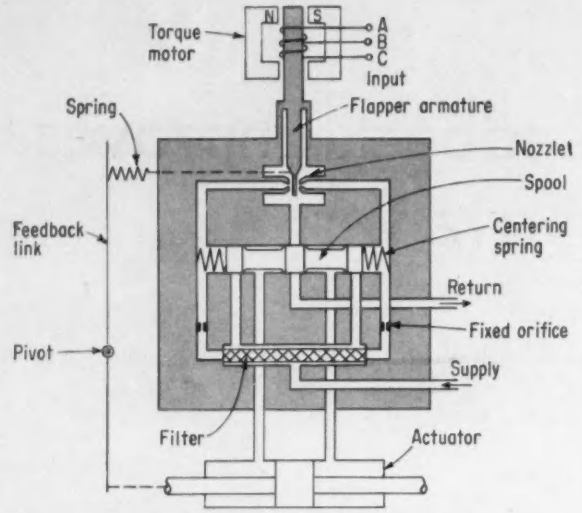


FIG. 2. Position feedback applied to a flow control servovalve by link and spring from actuator to flapper.

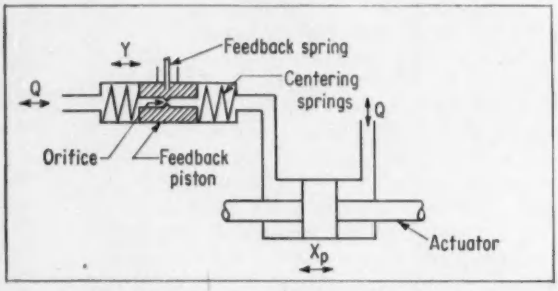


FIG. 3. Piston with by-pass orifice for feedback of actuator velocity to flapper.

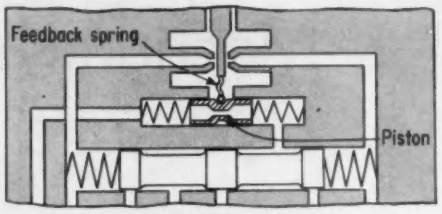


FIG. 4. Velocity feedback using piston of Figure 3 requires modified porting of flow-control valve.

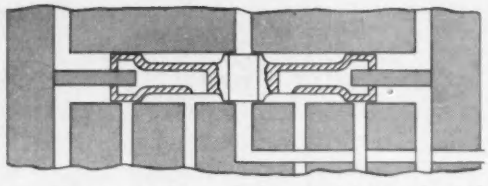


FIG. 5. Hollowed valve spool plus area reduction of outside end faces provides pressure summing for pressure-control valve.

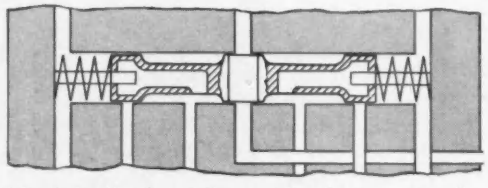


FIG. 6. Combination of flow control and pressure control techniques produces power-control servovalve.

filter network. Since the flow Q into the actuator is proportional to the actuator velocity $dx_p/dt = Q$. This flow develops a pressure drop across the orifice proportional to the flow rate or actuator velocity

$$\Delta P_{orifice} \approx \frac{d X_p}{dt} \tag{5}$$

The orifice pressure drop in turn develops an unbalance force across the piston which is balanced out by a force proportional to the spring rate of the centering springs times the piston deflection.

$$\Delta Y = \Delta P \approx Q = \frac{d X_p}{dt} \tag{6}$$

The deflection of the piston is fed back to the servovalve flapper via the feedback spring, Figure 4, to develop a force on the flapper. This force, in phase opposition to the initial error generating signal from the torque motor, produces a negative signal proportional to the system actuator velocity. Since the piston is spring-loaded to center and has a by-pass orifice, the washout or decay characteristic of an R-C network is achieved by the piston being returned to neutral by the springs forcing the entrapped oil on one side of the piston through the orifice.

Piston displacement Y is related to actuator displacement X_p by:

$$\frac{Y}{X_p} = \frac{C s}{\tau s + 1} \tag{7}$$

which is the dynamic response required to generate the velocity feedback characteristic.

The time constant, τ, is:

$$\tau = \frac{C_1 A_p n}{A_o K_p m} \tag{8}$$

where C_1 = proportionality constant
A_p = piston area
A_o = orifice area
K_p = centering spring rate
m, n = constants

The feedback gain C is controlled by the rate of the feedback spring.

The principal advantages of this system are the elimination of a servo amplifier, feedback potentiometer, power supply and derivative network, substantial savings in testing, and greater overall reliability.

This system has been applied in the speed-control loop of a hot-gas turbine power supply, where the turbine speed must be controlled very closely for large changes in turbine load. Other applications are pending in jet engine speed control and rocket engine thrust control, where both static and dynamic errors must be limited to very low values.

Feedback modifications of servovalve performance

Feedback may also be incorporated within the basic servovalve to provide various commanded functions. The electrohydraulic servo control valve is essentially a multi-stage transducer and power amplifier. Electrical power in the milliwatt range is transduced to mechanical and hydraulic horsepower with a response time of a few milliseconds. By means of the basic torque motor and nozzle flapper pressure control stage, and relatively simple modifications, the controlled variable output of the servovalve can be made to be hydraulic flow rate, hydraulic pressure, or hydraulic power.

The basic flow control servovalve has been described in connection with the position and rate servos. A pressure control servovalve is a relatively minor modification of the flow control configuration. If, as shown in Figure 5, the spool centering springs are eliminated and pressure summing areas added to the ends of the spool, the cylinder port pressures can be fed back to the pressure summing areas out of phase with the first stage pressures such that the differential load pressure is directly proportional to the input coil current.

A hydraulic power control valve, Figure 6, is simply a combination of a pressure control and flow control servovalve. Inasmuch as hydraulic power is equal to the product of flow rate and differential load pressure, a servovalve which produces a product of output flow rate and pressure proportional to input current, qualifies as a hydraulic power control device.

Figure 7 illustrates the input-current/load-flow characteristics of flow-, pressure-, and power-control servovalves.

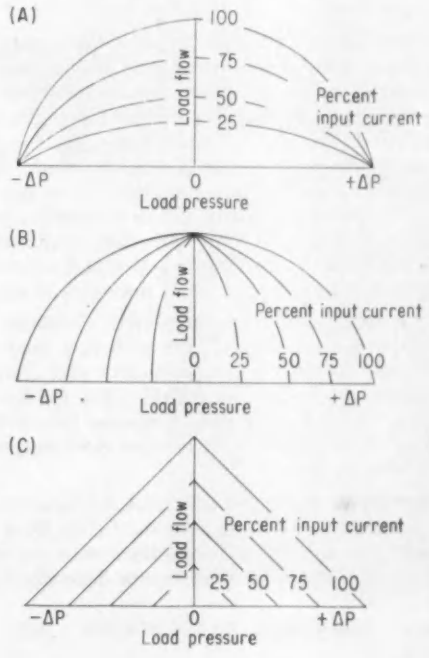
The three basic servovalve configurations can be applied as follows:

- The hydraulic flow control servovalve, the most common version, finds use in servo systems from the instrument range up to high power systems. Typical applications are in aircraft power controls, missile controls, missile launcher tracking systems, tank turret controls, automatic tuning systems, etc.
- The pressure control valve is used in systems which have substantial load inertia forces. Flow control valves are essentially pressure switches because of their extremely high pressure gains, and when used in servo systems with high inertia loads have a tendency toward instability. The characteristic of the pressure control valve to modulate the force applied to the load as a function of input current greatly alleviates the destabilizing effects of load inertia.
- The power control servovalve has been developed to provide a compromise between the pressure control and the flow control servovalves. Its pressure gain is higher than that of a pressure control valve, thereby reducing any static position errors due to large static load forces; yet pressure gain can be reduced as much as is desired to produce the necessary force integration or load damping for system stability. Applications for the power control valve are typically power servo systems such as rocket engine position controls, missile launching and tracking systems, and fire control servo systems, where large load inertias are present.

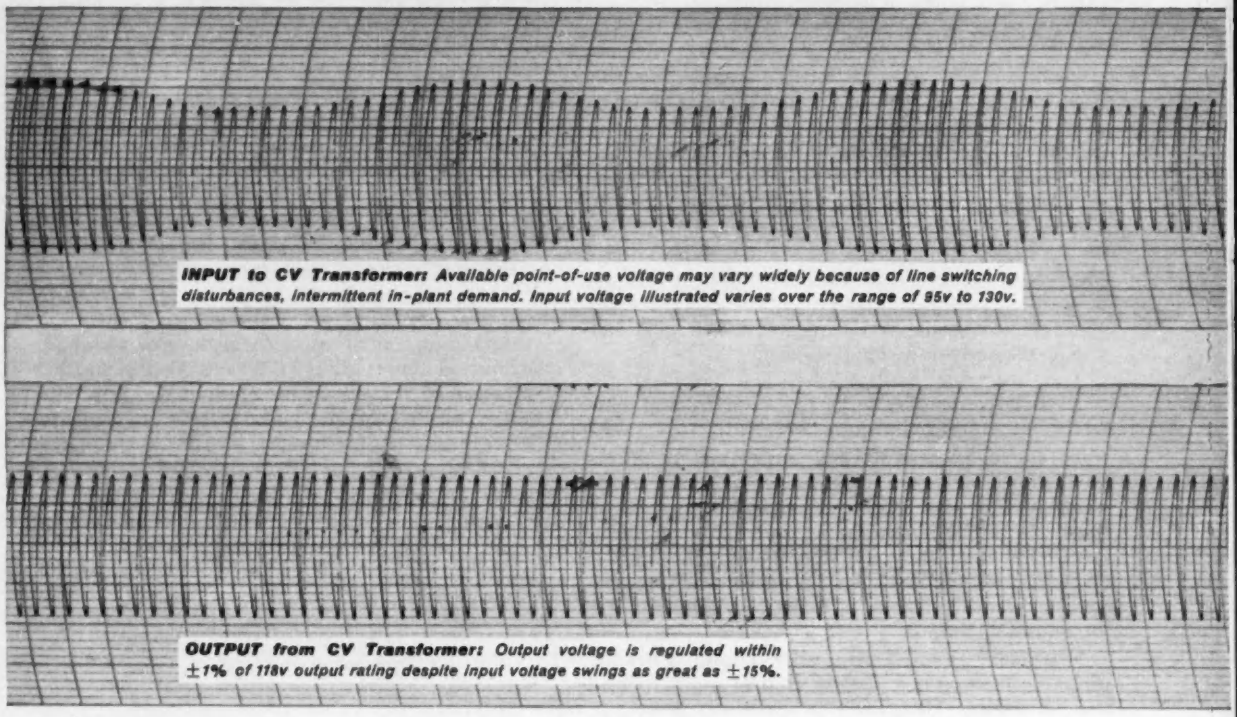
Experience with production applications of integrated hydromechanical servo systems has shown that the system simplifications due to elimination of electronic components pays dividends in overall system reliability. Generally it can be demonstrated that on a production system savings are possible in weight and space and in extensive component and subsystem tests, with these hydromechanical techniques.

In addition, criticisms of them on grounds of inflexibility are not valid. It is completely possible and practical for the customer to make loop gain changes of 10:1 or greater by simple adjustments. The electronic approach may be better in the initial breadboard development phase; however, a thorough analysis of the merits of simplified integrated control packages should be made for production systems.

FIG. 7. Input current vs. load flow for:
A—flow-control servovalve;
B—pressure-control valve;
C—power-control valve.



Get sinusoidal output from a ±1% static-magnetic stabilizer for the cost of voltage regulation alone



INPUT to CV Transformer: *Available point-of-use voltage may vary widely because of line switching disturbances, intermittent in-plant demand. Input voltage illustrated varies over the range of 95v to 130v.*

OUTPUT from CV Transformer: *Output voltage is regulated within ±1% of 118v output rating despite input voltage swings as great as ±15%.*

Sola now offers sinusoidal output in every standard-type regulator *with no price premium*. This development — a result of major design and production innovations — greatly widens the field of use for static-magnetic voltage regulation. The new standard sinusoidal design is now ideal for use with electrical and electronic equipment requiring a regulated input voltage with commercial sine wave shape — especially where harmonic-free supply had previously been too costly. The sinusoidal output also contributes to ease of selection and ordering, since this Sola stabilizer is virtually universal in application.

The Sola Standard Sinusoidal Constant Voltage Transformer provides output with less than 3% rms harmonic content. It automatically and continuously regulates output voltage within ±1% for line voltage variations of ±15%. Average response time is 1.5 cycles or less. The new line includes nine stock output ratings from 60va to 7500va.

Besides the improved electrical characteristics, these units are substantially smaller and lighter than previous models. Size and weight reductions were accomplished without any loss of performance or dependability.

With the Sola Standard Sinusoidal Constant Voltage Transformer you also get all the proved benefits of a static-magnetic regulator. It is simple and rugged. There are no tubes . . . no moving parts . . . no replaceable parts. Maintenance and manual adjustment are not necessary.

Its current-limiting characteristic protects against shorts on the load circuit. It is available in step-up and step-down ratios, allowing substitution for conventional, non-regulating transformers. These units can be used in any electronic or electrical application requiring a regulated sinusoidal power source where the peak power demand does not exceed the capacity of the constant voltage transformer. Circuit design formulae based on sinusoidal wave shape are directly applicable. Custom units to specific requirements are available in production quantities.

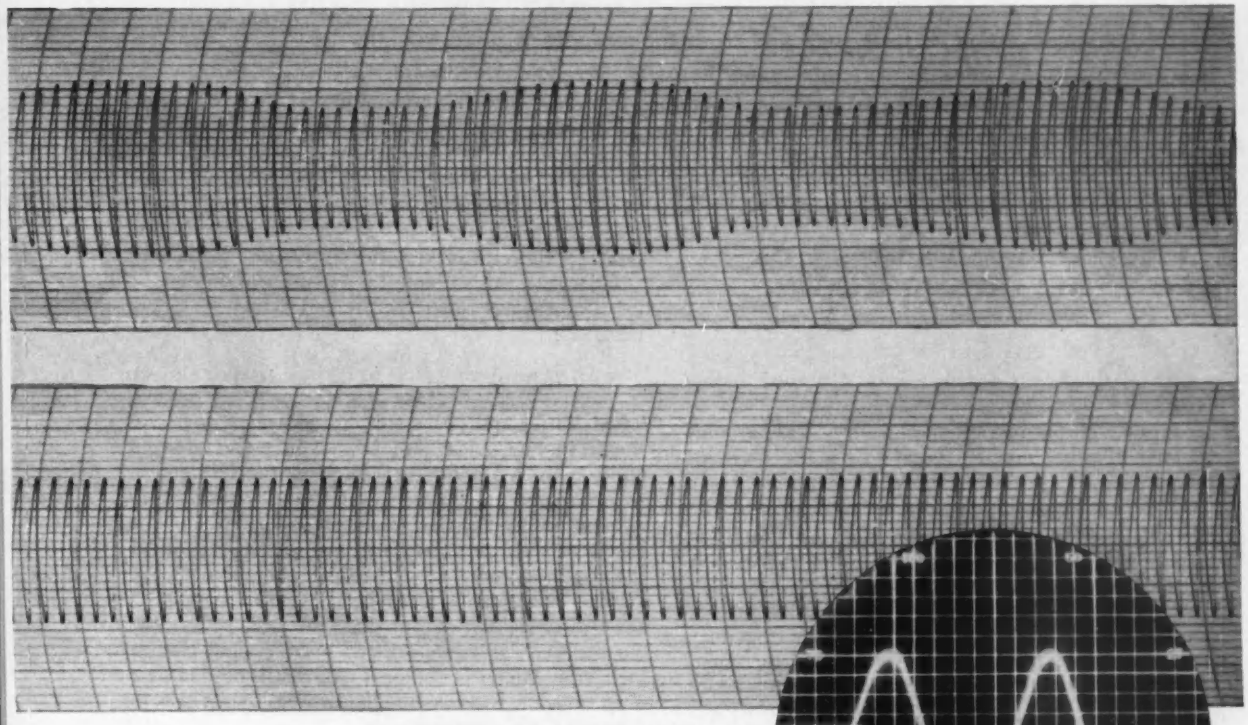
Write for Product Bulletin 26G-CVS.

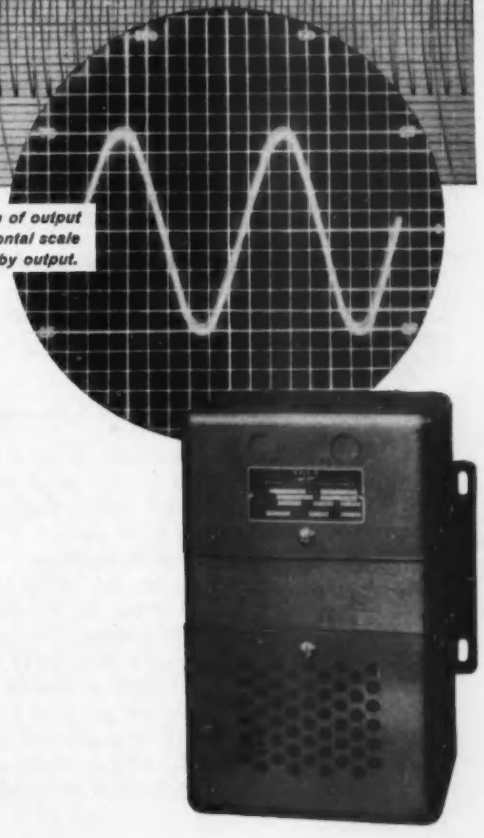
SOLA

SOLA ELECTRIC CO.,
4633 West 16th Street,
Chicago 50, Illinois

A Division of Basic Products Corporation

Sola Standard Sinusoidal Constant Voltage Transformer





OUTPUT from CV Transformer: *Oscilligram of output from same CV transformer uses expanded horizontal scale to picture commercial sine wave shape retained by output.*

New Prices of Sola Standard Sinusoidal Constant Voltage Transformers

Catalog Number	Output Rating, VA	Price Each	% Price Reduction
23-13-060	60	$30	6.2
23-13-112	120	38	5.0
23-13-125	250	52	17.5
23-13-150	500	81	14.7
23-13-210	1000	135	14.6
23-25-220	2000	245	10.9
23-25-230	3000	330	9.6
23-26-250	5000	515	new item
23-28-275	7500	900	new item

Interconverting Frequency and Transient Response

Interconversion of frequency and transient response is easy with the two sine and cosine cursors presented here by Dr. Rosenbrock. A six-step example shows that plotting one frequency-response graph and summing intercepts from the cursor is all that is needed to obtain transient response.

H. H. ROSENBROCK
Constructors John Brown, Ltd., England

Any stable linear system can be described mathematically in two ways:

1. The output corresponding to a sudden unit change of input may be given—this is the transient response.

2. A sinusoidal input may be applied, and the steady response of the system given in amplitude and phase angle at all important frequencies—this is the frequency response.

Transient response usually gives a clearer picture of the behavior of the system than does frequency response and is often easier to measure experimentally. On the other hand, frequency response is easier to calculate. It is therefore an advantage to have a method for converting one description quickly and easily into the other.

In describing the system by a transient response the variable is time, while frequency is the variable in frequency response. The mathematical formula giving the first in terms of the second is (in one of its several forms):

$$f(t) = H(0) + \frac{2}{\pi}\int_0^\infty \frac{IH(j\omega)}{\omega}\cos \omega t \, d\omega \qquad (1)$$

Here $f(t)$ is the transient response, $H(j\omega)$ is the frequency response expressed in the usual way as a complex number, and $IH(j\omega)$ means that only the imaginary part of $H(j\omega)$ is to be taken.

Equation 1 deserves careful attention. If t is given—say $t = 2$ sec—then the integral at the right presents no difficulty, and it can be calculated approximately by a number of graphical or numerical methods. But this gives only one point on the transient response $f(t)$. A fresh evaluation of the integral is needed for each new point of $f(t)$, and each time the integrand will be a different function of ω. The usual graphical methods demand that a new curve be drawn for each value of t; this is the chief stumbling-block in the way of a simple and quick method for making the conversion.

Changing the variable in the integral from ω to $\log \omega$ overcomes this difficulty and Equation 1 then becomes:

$$f(t) = H(0) + \frac{2}{\pi}\int_{\omega=-\infty}^{\infty} IH(j\omega)\cos \omega t \, d(\log \omega) \qquad (2)$$

Then $IH(j\omega)$ and $\cos \omega$ are plotted against $\log \omega$, as shown in Figures 1A and 1B. If now the curve of $\cos \omega$ is moved a distance $\log t$ to the left and is superimposed on the curve of $IH(j\omega)$, it represents in its new position $\cos \omega t$, Figure 1C. Multiplying the values of the two curves and taking the area under the resulting curve will then give the value of the integral in Equation 2 at time t. This procedure has still to be carried out once for each value of t, but the two curves $IH(j\omega)$, and $\cos \omega$ do not change their form when t is changed. All that is needed now is an easy way to carry out the multiplication and to determine the resulting area.

Figure 2 shows a practical way to make use of this idea. On a transparent cursor are ruled a number of vertical lines, each with an evenly-divided scale. (Two-color plastic cursors, 9-by-13 in., available, see note, page 120.) The distance between divisions on each scale is inversely proportional to $\cos \omega$, and if $\cos \omega$ is positive the part of the vertical line above the horizontal zero line is solid and the part below is dashed. If $\cos \omega$ is negative the dashed part of the vertical line is above the zero line and the solid part below.

If the cursor is placed over a graph of $IH(j\omega)$ against $\log \omega$ and the number of divisions on a vertical scale are counted between the zero line and the graph, then this number will give $IH(j\omega)\cos \omega t$ at that point. If the vertical scale is solid, then this contribution to the integral is positive; if the scale is dashed the contribution is negative. The sum of all these contributions from the vertical scales, taking account of sign, is an approximation to the integral in Equation 2.

The cursor carries a scale of t running from 1 to 10. This is read against $\omega = 1$ on the graph of

$IH(j\omega)$, or against $\omega = 10^n$, and the reading divided by 10^n. For example, if 2 on the scale lies over $\omega = 100$ then $t = 0.02$ sec. The scale of Figure 2 is correct for use on the graphical charts in Figures 1A, 1B, and 1C.

Several items need watching. First, the dimensions on the cursors are chosen so that the constant in front of the integral is $200/\pi$. Thus to obtain the integral required in Equation 2 the results from the cursor must be divided by 100. This assumes that the vertical scale used for $IH(j\omega)$ is the same as that shown in Figures 1A, 1B, and 1C—if not, due allowance must be made. Second, it is convenient to arrange things [by plotting $-IH(j\omega)$ instead of $IH(j\omega)$ where necessary] so that the largest area of the curve lies above the zero line. When this is done a negative result from the cursor will always indicate that $f(t)$ has overshot its final value. Third, if the curve of $IH(j\omega)$ overhangs to the right of the cursor, no allowance need be made for the omitted part. If it overhangs to the left of the cursor, or stops short within the grid at the left or on one of the six nearest vertical lines, certain rules apply:

Rule 1: If $IH(j\omega)$ behaves at low frequencies like ω, add five times the reading from the last vertical scale on the left cut by the graph.

Rule 2: In general, if $IH(j\omega)$ behaves at low frequencies like ω_r, add $[(5.5/n) - 0.5]$ times the reading from the last vertical scale.

As a short hand notation:

$$C\left\{IH(j\omega)\right\}$$

can represent the result of drawing a graph of $IH(j\omega)$ and using the cursor on it (with a selected value of t) as described above. Then Equation 2 can be written simply as:

$$f(t) = H(0) + 1/100\, C\left\{IH(j\omega)\right\} \qquad (3)$$

It will be noticed that in this method only one

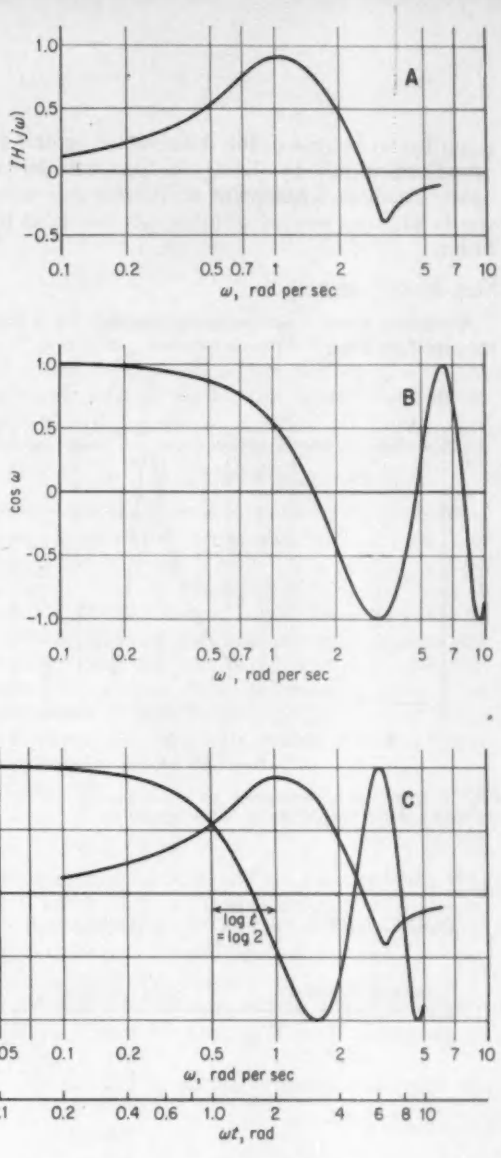


FIG. 1. Derivation of the method. A—graph of $IH(j\omega)$ plotted against log ω; B—cos ω plotted against log ω; C—when 1B is moved a distance log t to the left and superimposed on 1A the value of cos ωt at each point can be determined.

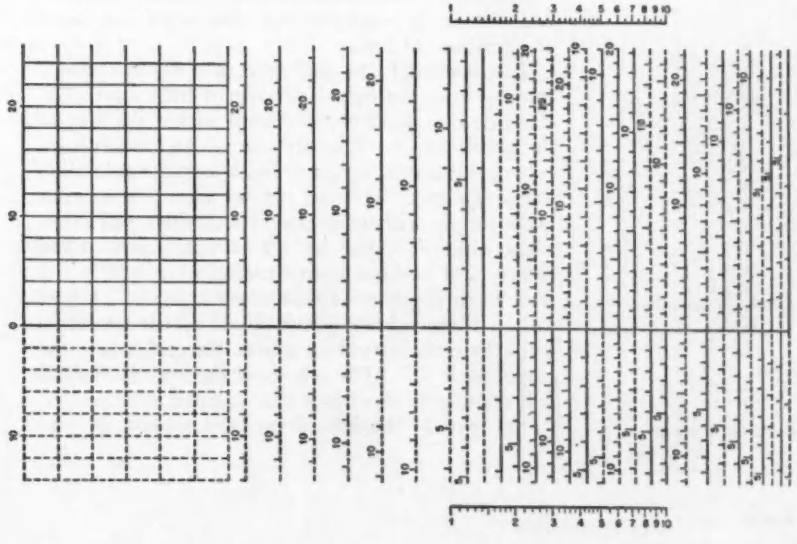


FIG. 2. The cosine cursor drawn to the same scale as in Figure 1. The horizontal scale represents $t = 1$ to $t = 10$.

graph has to be drawn; the different values of t are introduced merely by sliding the cursor to left or right. To obtain a new point of $f(t)$ it is only necessary to add up a new set of intercepts read from the cursor.

Step-by-step example

A position-control servo system has the closed-loop transfer function:

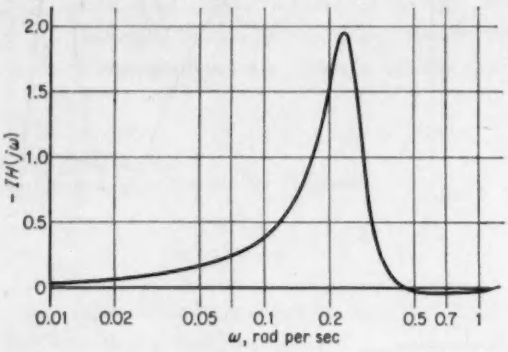


FIG. 3. Step 2 in interconversion on a position-control servo system is the plotting of—$IH(j\omega)$ against log ω.

TABLE–RESULTS FROM CURSOR FOR T = 15 SEC

Dashed (negative)	Solid (positive)
	0.1
0.3	
	0.3
	0.2
0.1	
	0.5
	1.5
4.9	
20.3	
17.3	
9.0	
3.7	
0.8	
	0.5
	1.2
	1.4
	1.4
	1.3
	1.2
	1.0
	0.9
	0.8
	0.7
	3.5*
−56.4	16.5
16.5	
−39.9	

* Five times the last figure (0.7) read from the cursor.

$$H(p) = \frac{1}{15p^3 + 18p^2 + 3p + 1} \tag{4}$$

Step 1 The value of $H(j\omega)$ is obtained by replacing p in this expression by $j\omega$, so that, remembering $j^2 = -1$, the result is:

$$H(j\omega) = \frac{1}{-15j\omega^3 - 18\omega^2 + 3j\omega + 1} \tag{5}$$

$$= \frac{1}{(1 - 18\omega^2) + j\,(3\omega - 15\omega^3)} \tag{6}$$

$$= \frac{(1 - 18\omega^2) - j\,(3\omega - 15\omega^3)}{[(1-18\omega^2)+j\,(3\omega-15\omega^3)]\,[(1-18\omega^2)-j\,(3\omega-15\omega^3)]} \tag{7}$$

$$= \frac{(1 - 18\omega^2) - j\,(3\omega - 15\omega^3)}{(1 - 18\omega^2)^2 + (3\omega - 15\omega^3)^2} \tag{8}$$

Here the fact that $(a + jb)\ (a - jb) = a^2 + b^2$ has been used to get rid of j from the denominator. The imaginary part of $H(j\omega)$ is thus:

$$IH(j\omega) = -\frac{3\omega - 15\omega^3}{(1 - 18\omega^2)^2 + (3\omega - 15\omega^3)^2} \tag{9}$$

Step 2 This expression, with its sign reversed, is plotted against log ω in Figure 3.

Step 3 The point on the transient response where $t = 15$ sec is now obtained by placing the cursor over the graph of $-IH(j\omega)$ with its zero line coincident with the zero line of the graph and with 1.5 on the horizontal scale over $\omega = 0.1$.

Step 4 The intercepts of the graph on the vertical scale of the cursor are shown in the table at the left, starting from the right.

Step 5 By counting them positive if the intercept is on a solid scale of the cursor, and negative if the scale is dashed, the intercepts are added to give:

$$C\left\{-IH\,(j\omega)\right\} = -39.9$$

so that

$$C\left\{IH\,(j\omega)\right\} = 39.9 = 40.$$

Step 6 The zero-frequency point is obtained by putting $\omega = 0$ in Equation 5, giving $H(0) = 1$. Then by Equation 3:

$$f\,(15) = 1 + 40/100 = 1.40 \tag{10}$$

Since the greatest area in Figure 3 is above the zero line, the result minus 40 from the cursor represents an overshoot of 0.40.

The intercepts in the table are written down, starting from the right-hand side of the cursor. On this side the graph becomes zero within the area of the cursor and no difficulty arises. At the left-hand side of the cursor the graph has a long tail extending across the grid. This tail can be taken into account quite simply without adding up all the small intercepts which it makes on the vertical scales of the cursor, and without even drawing it in. It is evident from Equation 9 that when ω is small $IH(j\omega) \approx 3\omega$. Then, following Rule 1, add up the intercepts until the sixth vertical scale from the grid, where the intercept is 0.7. The whole of the rest of the tail will contribute five times this amount, or 3.5.

The grid at the left of the cursor must be con-

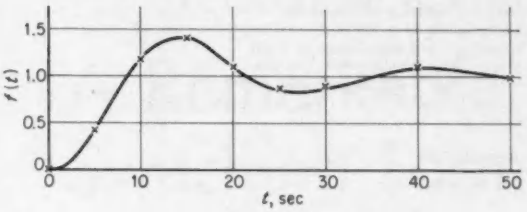


FIG. 4. The curve shows a mathematical solution for the transient response of Figure 3. The crosses compare results obtained by using the cosine cursor with those from an analytical method.

sidered to extend indefinitely to the left. To find the response at $t = 0$ the whole of the graph of $IH(j\omega)$ must be under the grid. In practice a part of the graph is dealt with and the cursor is then moved to bring a new region under the grid.

Analytical methods of determining the transient response for this simple example give:

$$f(t) = 0.0613 \exp(-1.0714\,t) + (0.9387 \cos 0.2410\,t + 0.5093 \sin 0.2410\,t) \exp(-0.0643\,t) \quad (11)$$

The two results are shown by the graph in Figure 4; the crosses show points obtained from Figure 3 by means of the cursor. In this example the analytical solution requires little more work than the graphical method. As $H(j\omega)$ becomes more complicated, however, the analytical solution rapidly becomes more difficult, while the work required by the graphical method increases only slightly.

If the closed-loop response is given as a gain A and phase ϕ (both functions of frequency) then $IH(j\omega)$ is simply $A \sin \phi$. Work can often be saved by obtaining $IH(j\omega)$ for the closed loop from open-loop data. Graphical methods for doing this are given in Refs. 1 and 2.

Frequency response from transient response

The reverse transformation is given by this formula (among others):

$$H(j\omega) = f(\infty) + \omega \int_0^\infty [f(t) - f(\infty)] \sin \omega t \, dt + j\omega \int_0^\infty [f(t) - f(\infty)] \cos \omega t \, dt \quad (12)$$

To evaluate this the cosine cursor already described is needed as well as a second cursor based on $\sin \omega$ instead of $\cos \omega$. Details of the sine cursor are shown in Figure 5. In using the sine cursor, the allowance to be made if the curve runs over the left-hand side is $[5.5/(n+1) - 0.5]$ times the reading from the last vertical scale.

If the result of using the sine cursor is denoted by S, then Equation 12 is equivalent to:

$$H(j\omega) = f(\infty) + \frac{\pi\omega}{200} [S\{t[f(t) - f(\infty)]\} + jC\{t[f(t) - f(\infty)]\}] \quad (13)$$

Thus by plotting the graph of $t[f(t) - f(\infty)]$ against $\log t$, and using successive applications of the sine and cosine cursors with a given setting of ω on the horizontal scale, $H(j\omega)$ for this value of ω is determined as in Equation 13.

Care must be used with Equation 13 because

$$C\{t[f(t) - f(\infty)]\} \text{ and } S\{t[f(t) - f(\infty)]\}$$

should both tend to zero as ω tends to infinity. Owing to inevitable errors they will not decrease below a certain value (about 1 or 2 percent of their maximum) and on multiplying by ω the error in Equation 13 may become large. Thus Equation 13 is only suitable at the low-frequency end of the response. This difficulty is inherent in the problem because $f(t)$ contains less precise information about the response at high frequencies than it does about the low-frequency response. A better formula, where it can be used, is:

$$H(j\omega) = f(0) + \frac{\pi}{200}\left[C\left\{t\frac{d}{dt}f(t)\right\} - jS\left\{t\frac{d}{dt}f(t)\right\}\right] \quad (14)$$

In this equation $f(0)$ should be evaluated just after $t = 0$, and a jump in $f(t)$ at $t = 0$ should be ignored when calculating $d/dt\, f(t)$. The differentiation in Equation 14 may be troublesome, but there are two situations where the formula can be useful:

1. Where the response $h(t)$ to a unit impulse is available. Since $h(t) = d/dt\, f(t)$. Equation 14 can easily be used.
2. Where $f(t)$ is calculated numerically, and can

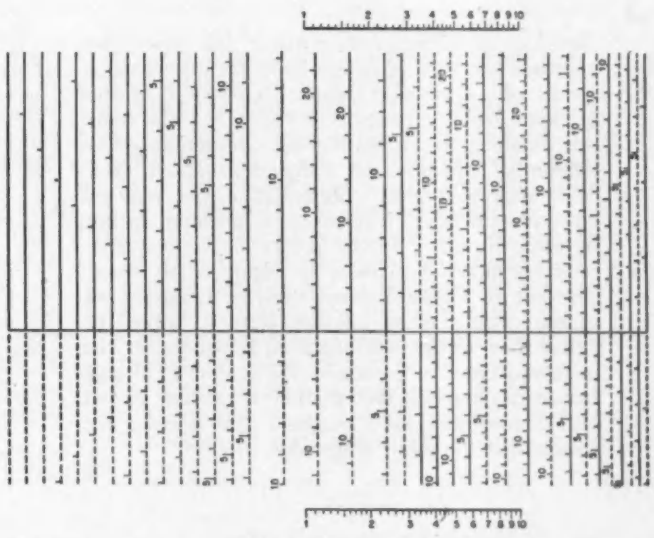


FIG. 5. Sine cursor.

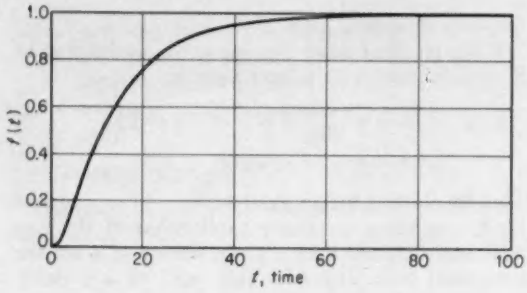


FIG. 6. Transient response $f(t)$ of the top plate of a five-plate enriching section to a step-change of feed composition. The response was calculated using a digital computer.

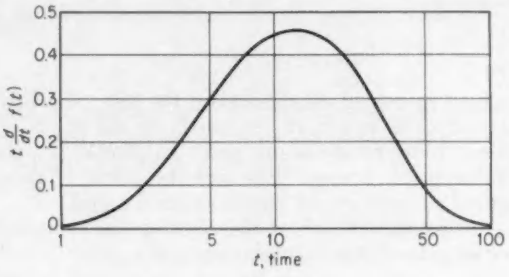


FIG. 7. Graph of $t\ d/dt\ f(t)$ against log t, where the curve was obtained by numerical differentiation of the results from the computer. Ordinate is not to scale of Figures 2 and 5, but abscissa is.

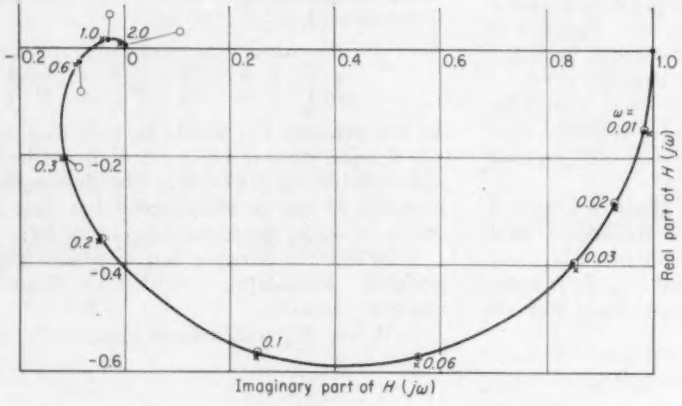


FIG. 8. Solution of the frequency response $H(j\omega)$ corresponding to Figure 6. The graph and points show a mathematical solution. Crosses show results obtained from Equation 14, circles highlight the upper frequency errors occurring when using Equation 13.

therefore be differentiated without difficulty. This approach was used in determining the calculated response of a distillation column to a sudden change of vapor feed composition in Figure 6. The result was obtained by integrating the appropriate set of differential equations on a digital computer (Ref. 3). After numerical differentiation the required curve of $(t\ d/dt\ ft)$ is obtained as in Figure 7; then by using Equation 14 the points of the frequency response shown by crosses in Figure 8 are found. The line in Figure 8 shows the true frequency response calculated by another method, while the circles show results obtained from Equation 13. The increasing errors in the results of Equation 13 at high frequencies are well shown—they would not in fact lead to confusion, for it becomes clear in using the cursors that the result is spurious.

Note:

The cursors described in this article, as well as matching graph paper, are available from W. Johnson & Sons, 187 Tottenham Court Road, London, W.1, England. Sine and cosine cursors—40/-each; graph paper—14/per pad of 25 sheets.

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2. *SOME GRAPHICAL METHODS IN FREQUENCY ANALYSIS*, H. H. Rosenbrock, "Transactions Society of Instrument Technology", 1956, 8, p. 30.
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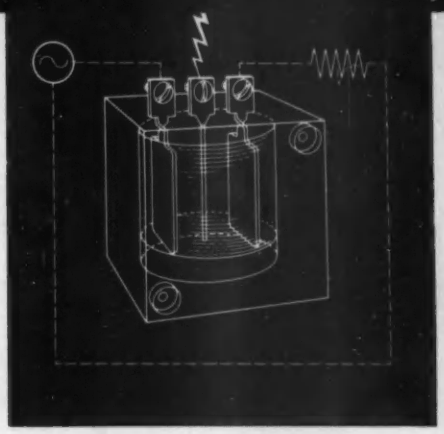
THE ELECTROCHEMICAL RELAY:

A Remarkable New Switching Form



Since its very beginning, the concept of static switching has drawn on two of the fastest-moving sciences of the era: magnetics and solid-state physics. Now from a different and most unlikely direction (electrochemistry) comes the latest component for making and breaking electrical circuits without the use of contacts.

JOHN D. COONEY
Control Engineering

What it is:

The headpiece picture dramatically shows the simple design of a promising new control component—the electrochemical relay. The two large plates are the main electrodes or "load contacts", the rod in the center the control electrode. The housing is a block of glass or inert plastic having a completely sealed, hollowed-out chamber. This chamber contains a liquid electrolyte that covers the three electrodes. The uncomplicated unit built from these few elements is capable of controlling the flow of alternating current to external loads without the use of moving parts. The control means is a small dc current through the center rod; the control modes are full on—full off and modulation.

The development of the unit just described is the latest result of the search for reliable switching forms. The demand for reliability in control systems has stimulated a great deal of effort in all areas of component research. But in the switching field, the activity has been particularly intense—understandably so because the making and breaking of electrical circuits is without question the most common control function. Prior evidence of this activity was the emergence of magnetic amplifiers and transistors specifically designed for switching service. Like the magamp and transistor, the electrochemical relay is a static device capable of an unlimited number of operations without apparent wear or deterioration. Being simply constructed of common materials, it does not have the handicap of high cost that has slowed the widespread application of magamps. And the electrochemical relay is inherently suitable for handling high-current loads directly without the power amplification required by both transistors and magamps.

The operation of the electrochemical relay is based on a hitherto unrecorded phenomenon, newly discovered by Stanford R. Ovshinsky of Ovitron Corp. The principle can be demonstrated by means of the schematic diagrams shown in Figure 1. The dashed lines represent the chamber containing the electrolyte bath, which consists of a solution of acid and free metal ions. The outer plates are the load electrodes, which are made of some film-forming material, such as tantalum. The current rating of the relay is directly proportional to the area of the load electrodes. The control electrode is an acid-resistant platinum rod located equidistant between the two outer electrodes. One of the main electrodes is connected to the load and the other to the ac supply. The relay cannot presently handle direct currents.

Two diode rectifiers are connected to the output terminals of the relay back to back. The purpose of these diodes is to supply dc bias voltage to the control electrode when the switch is closed. The value of the current passed by the diodes is low and noncritical so that small, inexpensive units may be used. They do not contribute measurably to the output current of the relay.

Under the open circuit conditions of Figure 1A, there is no dc voltage at the center electrode. The path between the main electrodes exhibits extremely high resistance and there is no current through the load. In Figure 1B, the control switch is closed so that the center electrode becomes positive with respect to the load electrodes. Instantaneously, the resistance between the main electrodes drops to a low value and alternating current is delivered to the load. If the control switch is replaced by a potentiometer, the output current can be varied as a function of the potentiometer setting or, in other words, in proportion to the control current. Thus, the electrochemical unit will function not only as a

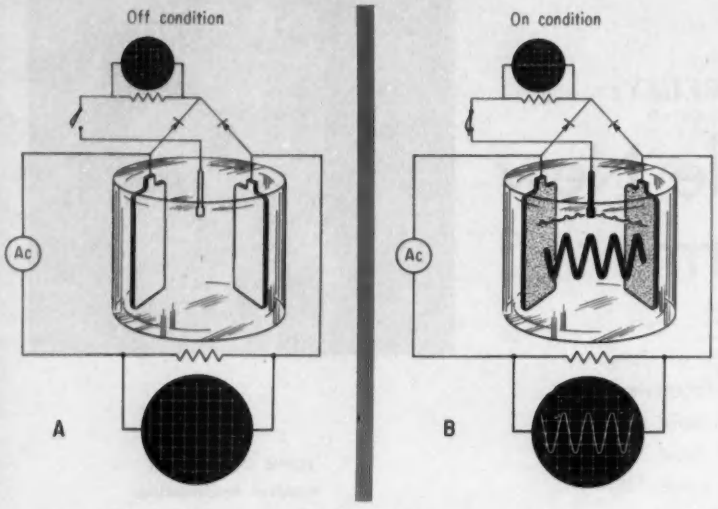


FIG. 1. Schematic diagrams show de-energized (A) and energized (B) conditions for electrochemical relay.

relay but as a power modulating device.

Despite the fact that the electrochemical switching phenomenon is readily demonstrated, there is as yet no full explanation of what actually occurs within the electrolyte. There are some clues to be found in the research literature on electrolytic capacitors; but it is apparent that the switching action involves extremely complicated ionic behavior which has eluded description, up to the present at least. It is a well known fact that insulating oxide films are formed on certain materials when they are immersed in an electrolytic solution. Indeed, this is the principle employed in the construction of the dry electrolytic capacitor, wherein the only function of the electrolyte is to form such a film on the rolled foil, thereby providing an efficient (and economical) insulating barrier between adjacent layers of foil. If it is assumed that such oxide films are formed on both of the load electrodes, these can be regarded as fully insulated from one another and no current can pass between them. Now, when the control electrode is given a positive charge with respect to the load plates, the insulating particles that constitute the oxide layers are changed, in effect putting the conductive metal of the load electrodes into full contact with the electrolyte. Thus begins a two-way interchange of negatively and positively charged ions that act as "current carriers" between the load electrodes. As soon as the positive charge is removed from the control electrode, the insulating films are instantaneously reconstituted and further conduction through the relay is blocked.

While this oversimplification of the switching phenomenon will suffice for the purposes of this article, a full and true account of what actually occurs remains to be given. Ovitron Corp. scientists have advanced a complex theory of operation, which is at least as plausible as the "carriers and holes" concept devised to explain transistor action. Their theory recognizes the fact that ionic transport speeds through the electrolyte are far below that necessary to follow the polarity changes caused by the sine wave of voltage across the load electrodes. Therefore, the flow of current cannot be credited to ions traveling the complete path from one load electrode to the other. It is felt that the control potential acts merely as a force to align the ions to permit the movement of charges from one to another. The switching action, however, is a result of surface phenomena at the load electrodes. The electrolyte serves only as the conducting medium.

What it Does:

The electrochemical reaction associated with the passage of ac load current is a redox reaction, with reduction and oxidation taking place at equilibrium rates. Hence there is no gassing or transfer of electrode materials due to load current. The dc control currents do generate some gas at the electrodes, but this is returned to solution by the catalytic action caused by a small wire protruding into the sealed electrolyte chamber, Figure 2. A semi-permeable membrane separates the liquid electrolyte from the empty upper section of the chamber. Gases flow through this membrane to come into proximity with the catalyst wire, recombine into another gas form, then return through the membrane back into solution. The membrane is impervious to liquid.

The plastic housing shown in Figure 2 is from a lot of one prototype model of electrochemical relay manufactured for test and sampling. The complete relay is of plug-in design, measures 1.5 in. high by 1.5 in. in diameter, and has a "load contacts" rating of 4 amp, 70 ac volts rms. In current design work on the relay, the 70-volt figure has been established as the working maximum. It is expected that this limitation will be raised as the development progresses. The peak voltage that can be handled by the electrode clearances seen in Figure 2 is 140 volts; if the supply voltage is raised much beyond this, the electrolyte will conduct regardless of whether or not the control electrode is energized. Because severe overcurrents accelerate gassing, the

sealed units are designed to fail safe (open-contact) should hazardous pressures be approached. There is also a minimum or "dry-circuit" voltage that the load electrodes can handle satisfactorily. For the unit described, this minimum is 3 volts. By providing some means for pulsing the control electrode, the minimum can be dropped to 1.2 volts.

Figure 3 is an oscillogram of the waveforms of the current in the control and load circuits of the electrochemical relay. The conditions for this particular test were as follows: supply voltage—30 ac volts; load resistance—65 ohms; ac load current—450 ma; dc control current—18 ma. The oscillograph leads were connected across 1-ohm resistors in the control and load circuits. The load current remains a true sine wave and is apparently unaffected by passage through the electrolyte. Pulses of dc control current occur at the peaks of the supply voltage.

When the unit is conducting, the impedance between load electrodes is approximately 2 ohms. At the instant of make, it is slightly higher but stabilizes at a constant value after a short time. The impedance changes minutely with variations of load current, being actually less for the higher values of output current. In a specific case, the impedance drops about 0.25 ohms when load current is doubled. For constant-loads, the impedance does not vary between closures or over extended periods of use.

The current capacity of the electrochemical relay is dependent on the area of the load electrodes. By increasing this area through the use of larger plates or by making the electrodes from a sintered porous material, current capacity can be raised without affecting the overall size of the unit. However, the increase of electrode area makes for greater interelectrode capacitance and thus is accompanied by a rise in the open-circuit leakage current through the relay, which may be detrimental in some applications. The curves of Figure 4 show the relationship between supply voltage and leakage current for two different electrode sizes. It is important to note that leakage current can be reduced by putting two or more relays in series, so that each unit takes only a portion of the total applied voltage. By this same expedient, the usefulness of the electrochemical relay can be extended to circuits above 70 volts.

There is a definite relationship between load current and control current. If the relay is conducting, any change in load current is immediately accompanied by a proportional change in control current. The change is automatic, being made by some phenomenon within the surface electrolytic reaction. In the design of a given relay, the parameters can be chosen to provide any one of a wide range of ratios of load current to control current; the range extends from 10:1 to 50:1 and higher. The speed of response is greater at the lower ratios.

The dependence of load current on control current is made use of in applications of the electrochemical relay to power modulation. For operation

FIG. 2. Interior view of electrochemical relay shows load electrodes, control electrode (right, center), and wire catalyst.

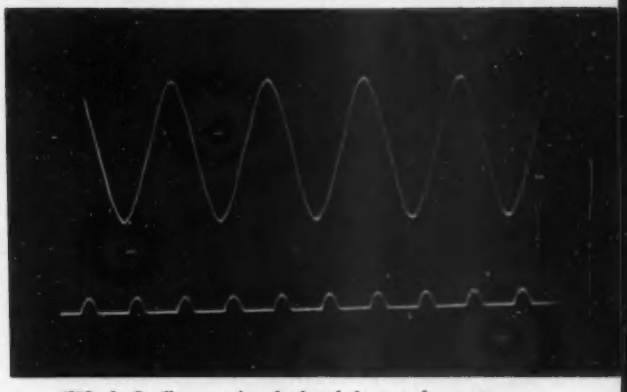


FIG. 3. Oscillogram of ac load and dc control currents.

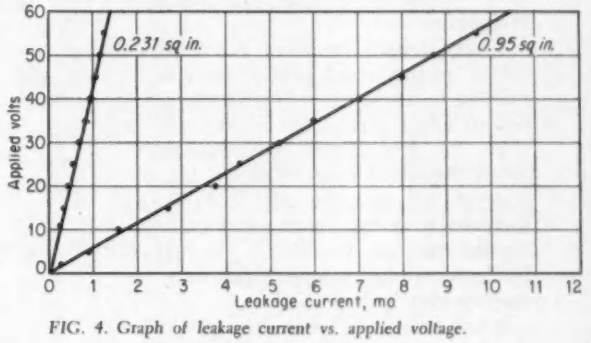


FIG. 4. Graph of leakage current vs. applied voltage.

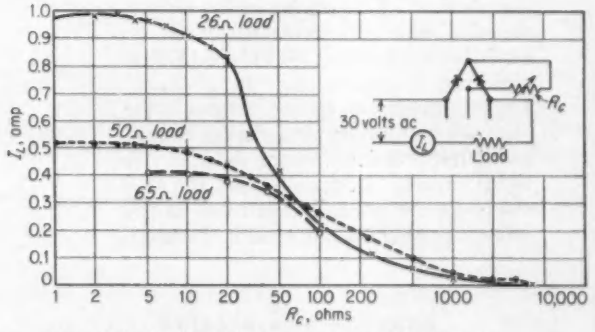


FIG. 5. Relationship of load current to control resistance.

in this mode, the switch in the control circuit is replaced by a potentiometer as shown in Figure 5. Also shown are curves of load current vs. control resistance for three different values of load resistance. The relationships are nonlinear, especially at the lower values of load resistance; however, like electron tubes, the relays can be so applied as to operate in the linear range.

In the matter of speed of response of load current to control signal, the electrochemical relay is somewhat similar to the magamp. Response is definitely related to the frequency of the applied voltage. Load current rises to 75 percent of the steady-state value in the first half cycle. The magnitudes of supply voltage or load current have no effect on response. Oscillograph studies reveal that the relay makes the load circuit without any bounce or erratic energization whatsoever.

The "break" time of electrochemical relays can be varied to suit specific application requirements. During response tests, the load circuit has been opened within from one-half to three cycles of the 60-cps applied voltage under various conditions. The magnitude of the applied voltage does have a slight effect on the speed of de-energization, but varying load current within rating has no measurable influence. Increasing the frequency of the applied voltage improves the response of the electrochemical relay on both make and break. Studies of new grid-control techniques indicate that it will be possible to increase switching speeds considerably.

The rated temperature rise of the units is 55C. Their operation is relatively stable over ambients from minus 10 to plus 150C, and is unaffected by vibration, shock, impact, moisture or position. Although relays for extremely high temperatures have not yet been built, it is felt that both temperature and current-carrying capabilities can be extended by furnishing units with some integral means of circulating and cooling the electrolyte. External magnetic or electrostatic fields have no effect on the performance of the electrochemical relay.

How it is Used:

Although Ovitron engineers are presently concentrating on the development of relays and power modulators, it is felt that the principle may find use in a whole family of switching and control devices: proximity switches, logical units, regulators, modulators, amplifiers, error detectors, circuit breakers, etc. Figure 6 is a schematic diagram of an electrochemical overload relay designed to test the applicability of the principle to circuit protection. This design makes use of the fact that control current is an automatic function of load current, as shown by the graphs.

Under normal conditions the control contacts are closed, so that rated current flows to the load. An increase in load current beyond the safe value, develops sufficient flux at the control coil to open the low power control contacts. With the control circuit open, the impedance between the output electrodes increases to its maximum value eliminating the overload condition. The magnet holds the control contacts open until the reset button is depressed.

It will be noted that in the orginal configuration depicted in Figure 1, the load and control circuits are not isolated from one another. This version of the electrochemical relay, therefore, would not be a suitable replacement for the electromagnetic relay in conventional control circuit. For this reason, two special versions of the electrochemical relay were designed, both giving full isolation between the load and signal circuits. In one of these, the load electrodes are normally open and in the other they are normally closed. Isolation is achieved by means of small economy-grade filament transformers, whose secondaries control the action of transistors operating in the switching mode.

The astounding novelty of its operating principles assure the electrochemical relay of a quick and thorough trial in control circuitry. It is still too early to predict the outcome or what effect the unit will eventually have on switching practice. As is the case with most new developments, widespread application will certainly uncover shortcomings. It is equally probable, on the other hand, that more highly refined units will emerge with time. For the present it can be said only that the electrochemical relay is static, simple, wearproof—and it works.

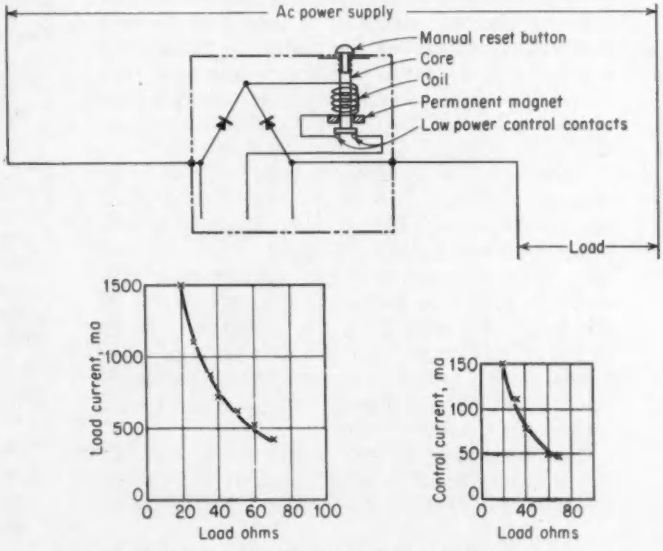
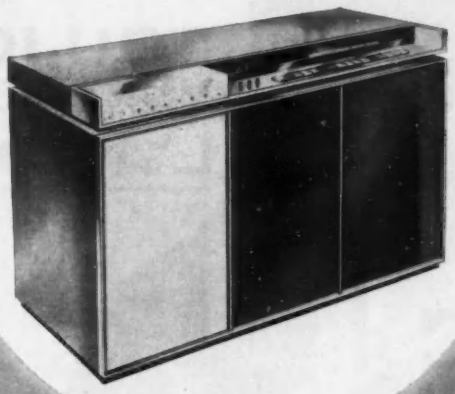


FIG. 6. Schematic diagram of circuit protector and curves showing the variation of control current with load.



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NUMBER: 8, expandable to 512 with additional optional plug-in components.
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VOLTAGE RANGE: 0-1 and 0-10 (or more) volts d.c.
MANUAL: Flexowriter and punched paper tape.
DIGITAL CLOCK: Internal, pure binary, real time to provide time of day for logging.

OUTPUTS
Flexowriter and punched paper tape; and computer logic producing 10-bit addressable word to actuate relays for control signals.
SPEED AND NUMBER: 66 outputs per second; time-sharing permits unlimited number.
SEQUENCE: By computer command; changeable by program.
TIME READOUT: From digital clock.
TYPICAL OPTIONAL CONTROL FUNCTIONS AVAILABLE: Alarms, voltage level, bridge balance, relay closure, setpoint, reset rate, proportional band, variable time delay, recorder, plotter.

GENERAL SPECIFICATIONS
COMPUTER TYPE: General-purpose digital.
NUMBER BASE: Binary.
MODE OF OPERATION: Serial.
INSTRUCTION TYPE: Single address.
NUMBER OF DIFFERENT INSTRUCTIONS: 16
MEMORY TYPE: Magnetic drum.
MEMORY CAPACITY: 4096 words.
WORD LENGTH: 30 bits plus sign.
CLOCK FREQUENCY: 136 KC
ADD TIME (Excluding Access): 0.25 milliseconds.
MULTIPLY TIME (Excluding Access): 15 milliseconds.
WEIGHT: 1000 lbs. nominal.
SIZE: 30″ x 42″ x 60″.
POWER REQUIREMENTS: 117 volts (±10%) 17 amperes 60 cycles.

OPTIONAL EQUIPMENT
PHOTOELECTRIC READER: High-speed punched paper tape input for buffer storage.
MAGNETIC TAPE: Storage for additional input, output, and computing information.
MAGNETIC-CORE MEMORY: For quick access to stored data.
PUNCHED CARD INPUT.
LINE PRINTER: High speed data-logger printing 14 digits at a time.
TYPEWRITER SELECTOR: For multi-station printout.
RELAY SENSING EQUIPMENT: For changing computer program in accordance with plant or product requirements.
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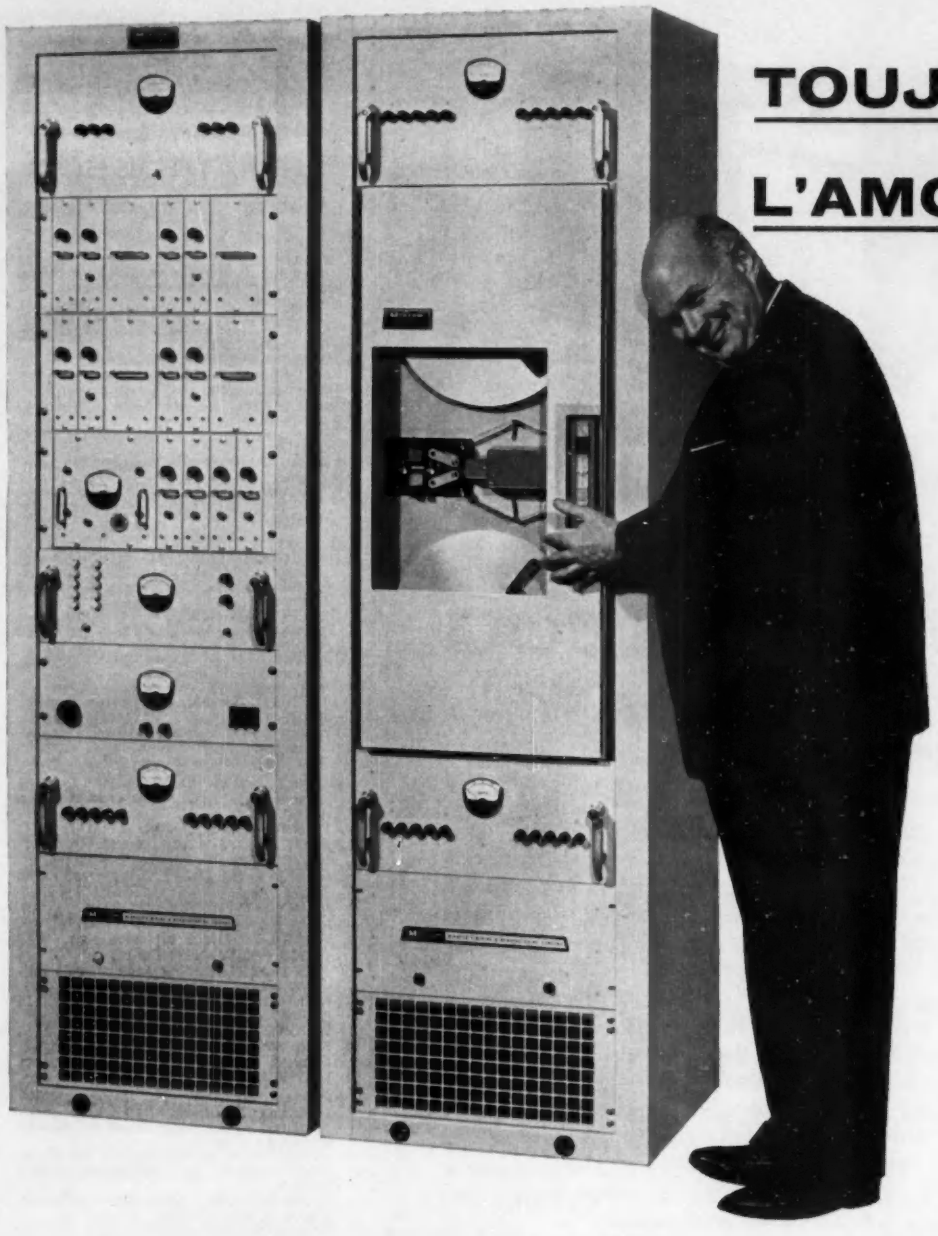

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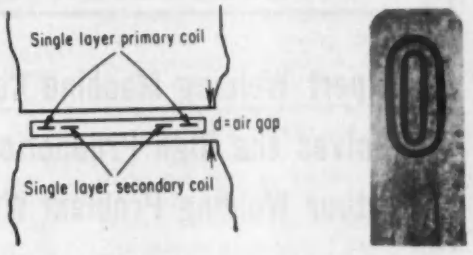


FIG. 1. A—Cross-section of the transducer in an air gap. B—Single layer transducer coils of No. 44 wire. Both coils have 40 turns. Approximate dimensions of middle turns: primary, 12.5 by 28 mm; secondary, 5 by 22 mm.

In manufacturing a medium-sized electrical machine, it is necessary to adjust the position of the rotor in the air gap to keep manufacturing tolerance specifications economical. The conventional procedure is to measure the air gap between the rotor and the stator at several points around the periphery with wedge gages; but this has disadvantages. To begin with, it is a cut-and-try procedure that is not necessarily converging. That is, the rotor is placed in what seems to be the center position, using a crowbar arrangement, and locked, and the air gap is then measured at several points with the wedge gages. If this first guess is wrong, and it very often is, the whole procedure has to be repeated until the guess is within the tolerances specified.

A second disadvantage is the need to make the air gap accessible from both ends of the machine. In certain cases this may lead to uneconomical and impractical designs for cooling fans, bearings, and other details. Finally, the conventional wedge gages can give erroneous results because of random local irregularities.

A continuous measuring method now even makes it possible to measure the air gap at the remote end of the machine. The principle used is that the mutual inductance between two coaxial pancake coils arranged and placed as shown in Figure 1 is dependent upon the air gap.

Figure 2 shows the operation of the equipment. Four probes, used simultaneously, are placed in the 45-deg directions as shown. The primary windings of all the transducers are fed in series with constant current of power frequency (50 cps). Amplifiers A1 and A2 have phase-sensitive rectified outputs, and inputs consisting of the difference between the output voltages of transducers 1-3 and 2-4, respectively. Outputs of the amplifiers are connected to two conventional moving-coil meter movements arranged in one instrument, as shown in Figure 2, with the pointers in 45-deg directions at zero-output from the amplifiers. The position of the center of the rotor in the air gap corresponds to the intersection of the pointers with respect to the center of the concentric circles on the meter.

The centering procedure is as follows: The probes are adjusted in the air gap one by one for maximum output on the millimeter (instrument II); in this way, they cannot be placed opposite a slot in either rotor or stator. The position of rotor is then adjusted until the pointers of instrument I intersect at the center. The rotor is locked in this position, and the transducers are placed at the other end of the rotor (with certain machines, it may be necessary to readjust the rotor position at the original end or to duplicate the equipment). Finally, the rotor is fixed by guide pins.

There are three reasons for utilizing the mutual inductance between two coils instead of the self-inductance of one coil. First, the impedance of a single-layer coil in an air gap, as in

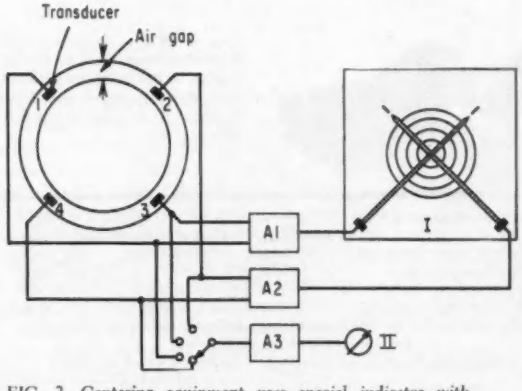
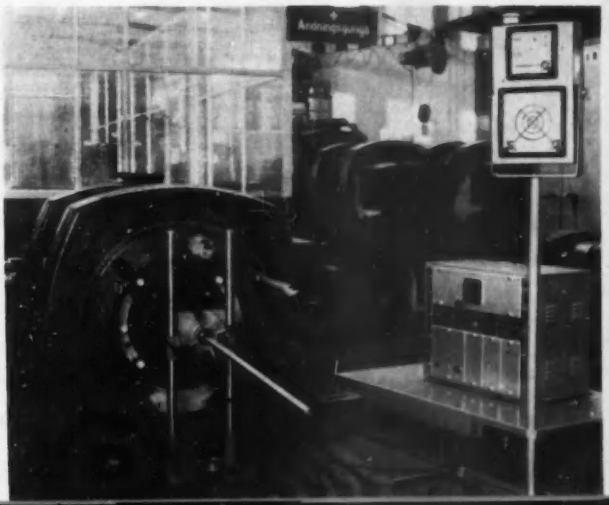


FIG. 2. Centering equipment uses special indicator with two moving coil-meter movements zeroed at 45 deg as shown.

FIG. 3. Centering equipment set up for use.



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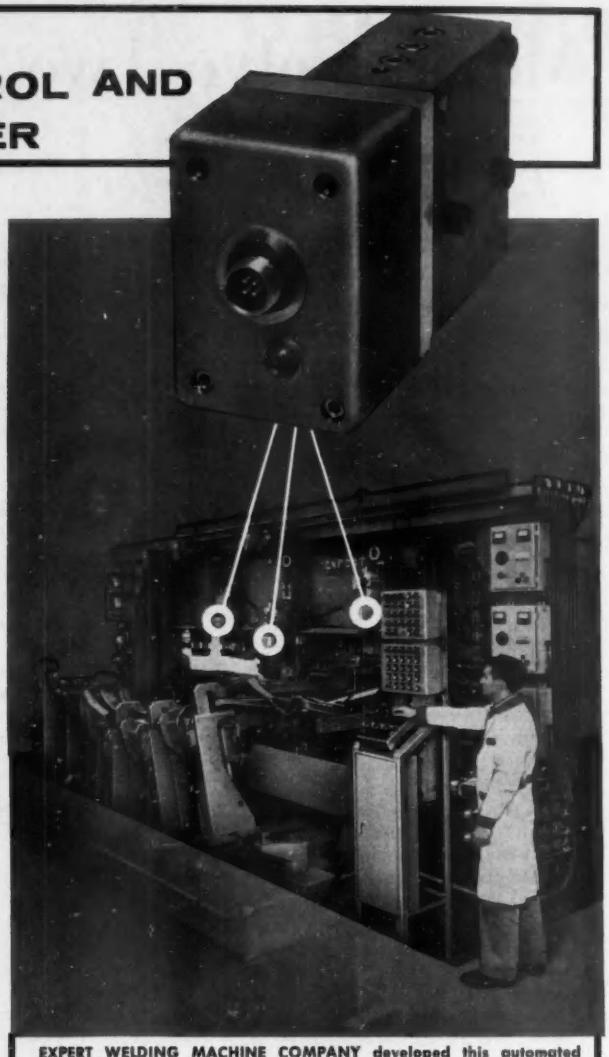

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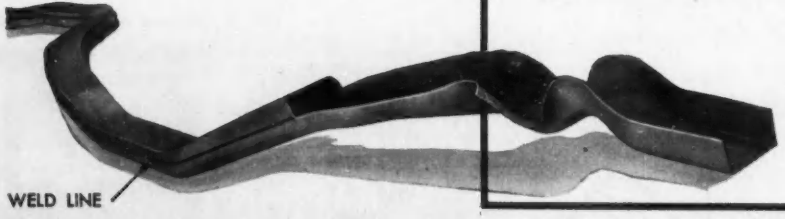

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Figure 1, is mainly ohmic, which means that variations in the self-inductance due to different air gaps will be difficult to detect. Second, the lines of magnetic flux in the air immediately surrounding the current-carrying coil will contribute very little to the mutual inductance (they have a great influence on the self-inductance of one coil). Finally, with mutual inductance, the position of the transducer in the air gap is not critical (self-inductance is somewhat dependent upon this position).

The coils used have the dimensions shown in Figure 1, and are placed between two strips of impregnated paper, which are glued together. The coils are located at one end of a probe 800 mm long by 23 mm wide by 0.3 mm thick. The other end has a plug.

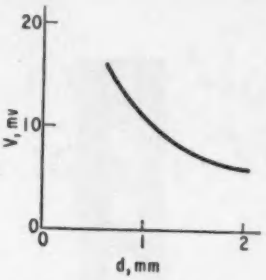


FIG. 4. Transducer output voltage versus air gap when excited by 0.15 amps, 50 cps.

The output voltage of the transducer as a function of the air gap is plotted in Figure 4. The curve is approximately hyperbolic ($V = k/d$), and applies to 3 percent silicon iron laminations. Measurements show that the output voltage is independent of the position within the gap.

The equipment has been used in production for some time. Accuracy is quite satisfactory—the error is less than plus or minus 0.05 mm. Figure 3 shows the equipment set up for use.

The air gap transducers may also be used for measuring a single air gap, by using a single transducer and a calibration curve having the general shape shown in Figure 4, or by balancing the output of two transducers, where one is placed in a calibrated and adjustable air gap and the other in the air gap to be measured. So far there has been no demand for such an instrument, and therefore the influence of the magnetic properties of the iron on transducer sensitivity has not been investigated.

2. Meter Relays Protect Punch Presses

FREDERICK C. MARX
The Heekin Can Co.

A modified machine overload control made by Tipptronic, Inc., is used at Heekin to protect punch presses and dies. Heekin's problems with punch presses had been caused by faulty feeding of the sheets for cans of various sizes and shapes, and by failure to remove sheet scrap. With presses running up to 300 strokes per min, instances of double-sheet feeding occur often enough to make protective controls necessary. Damage can also be caused by an unusually thick or hard single sheet.

The controls have also eliminated die breakage and have reduced man-hours spent in attending to other press failures, and thus have made possible higher production.

A thyratron-operated control was experimented with first, because of its fast response. But it required a "blind" screwdriver adjustment and had no provision for monitoring while the press was in action.

The modified machine overload control, finally used, is shown in one version in the accompanying diagram. It uses a meter relay (contact ammeter) to monitor one phase of the punch-press drive motor. Under normal conditions, with a single sheet in the press, peak phase current for the 5-hp, three-phase, 220-volt motor might be 12 amps; but if two pieces are placed in the die the peak phase current might jump to 16 amps. The adjustable meter contact is set while the machine is running, just above the current level for normal operation.

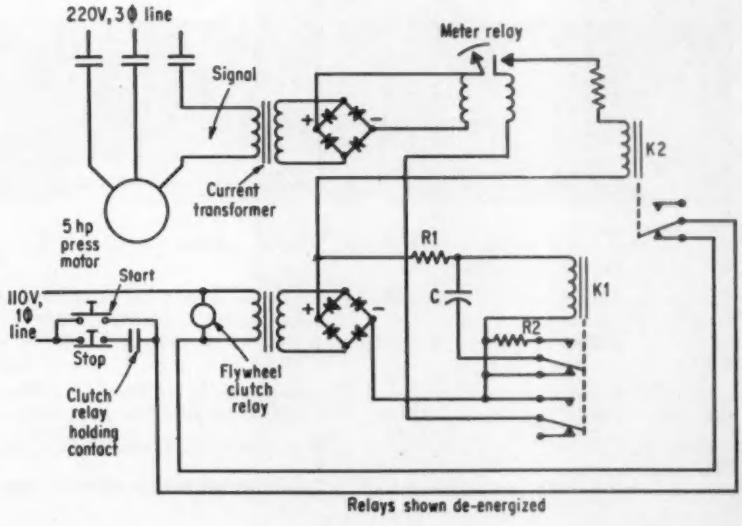
However, in the event that a double, or an unusually hard piece of material is fed into the die, the meter relay contact closes to stop the punch press ram. The Bliss Model 1831 punch presses at Heekin are equipped with solenoid-operated air clutches, and the control immediately takes all driving energy from the ram by disengaging the flywheel clutch.

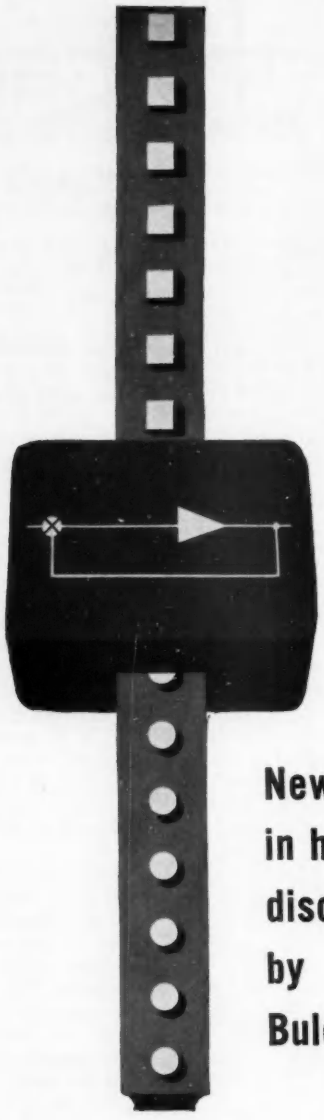
As shown in the diagram, the clutch is energized by the flywheel clutch relay, which holds itself closed through a series contact on relay K2. Actuation of K2 by the ammeter contact thus disengages the clutch. K2 is energized by a series contact on K1, which is in parallel with the clutch relay so that the meter contact circuit is active only when the machine is running. K1 has a time delay on closure, provided by C and R1, to prevent false actuation of the protection circuit by the inrush current when the press motor is started. R2 serves to limit the capacitor discharge current through the coil of K1, and causes no appreciable delay on drop-out.

On presses without the automatic clutch, the meter contact deenergizes the drive motor and activates a reversing starter that provides braking or plugging action for a controlled length of time—just long enough to stop the press.

The meter relay control continuously indicates the operating conditions while providing a simple adjustment of the trip-point. Thirty of Heekin's punch presses are now equipped with these controls.

Overload control as modified for punch-press protection.





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Reliable Level Measurement for Liquid Metals

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G. H. BURGER, Oak Ridge National Laboratory

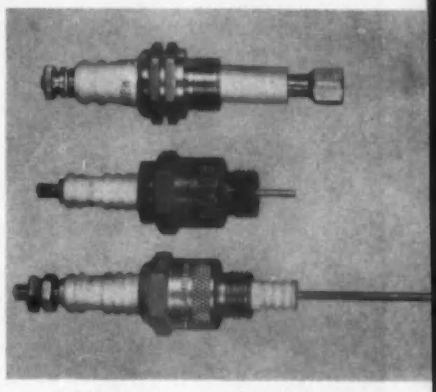


FIG. 1. Conventional spark-plug probes short across insulator or corrode away.

Accurate, reliable level measurement of liquid metals at high temperatures is a difficult, frequently encountered problem. And in reactor systems that use sodium and sodium-potassium alloys for coolant fluids, the problem is greater due to the radioactivity induced in the fluid. Here the level measuring system must be leak tight, because the escape of vapor or fluid could create a radioactive hazard to operating personnel.

A level device has been developed for systems in which a continuous indication of fluid level is not needed, such as in fill and dump tanks. Two level signals are used, one for full level, to control the dump valve, stopping flow into the dump tank and indicating when the system is fully drained, and one for low level, to stop the flow into the system when it is filled. Level over a fixed range can be controlled too, by placing two probes the required distance apart. The high or low levels can be indicated by lights, audible signals, or both.

The most widely used probe for an on-off or point-level measuring system has been the spark-plug probe, a standard plug with a long center electrode. Spark plugs with larger than normal insulators are also used (Figure 1). The plugs are inserted in the vessel in which the level is to be measured, and a 110-vac circuit established between the electrode and the tank wall. To indicate the level signal a lamp is inserted in series with the electrode. As soon as the fluid in the vessel touches the electrode the circuit is completed through the electrode, the fluid and the tank wall, causing the lamp to light.

Extensive tests of the spark-plug probes have proved them unreliable. At 450 to 950 deg F, the insulators were severely corroded, sometimes allowing vapor to completely penetrate the plug and always shorting the circuit. And at body temperatures below 450 deg F the plugs generally operate a considerable time before shorting, but are not satisfactory for long periods of continuous duty because of leaks.

A new probe was designed for the system mentioned, to overcome the limitations of the spark plug with respect to operating temperature and reliability. It operates by detecting a change in electrical current caused by

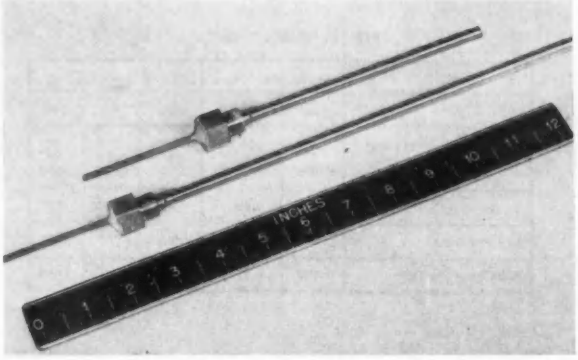


FIG. 2. New probes are made of Inconel, have no insulator to short out.

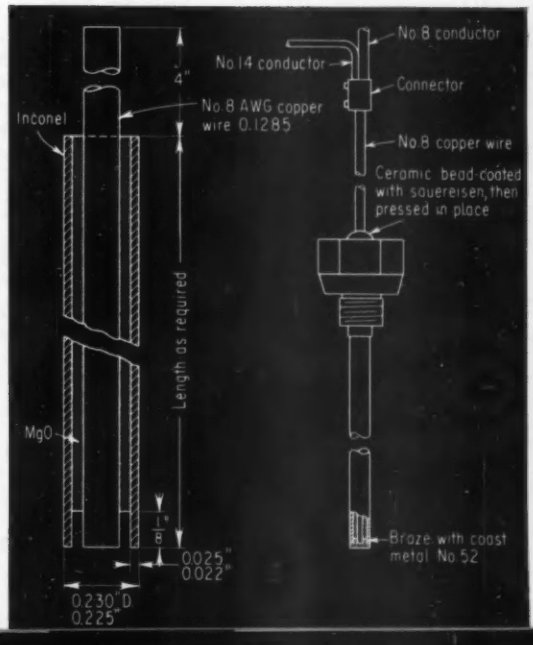
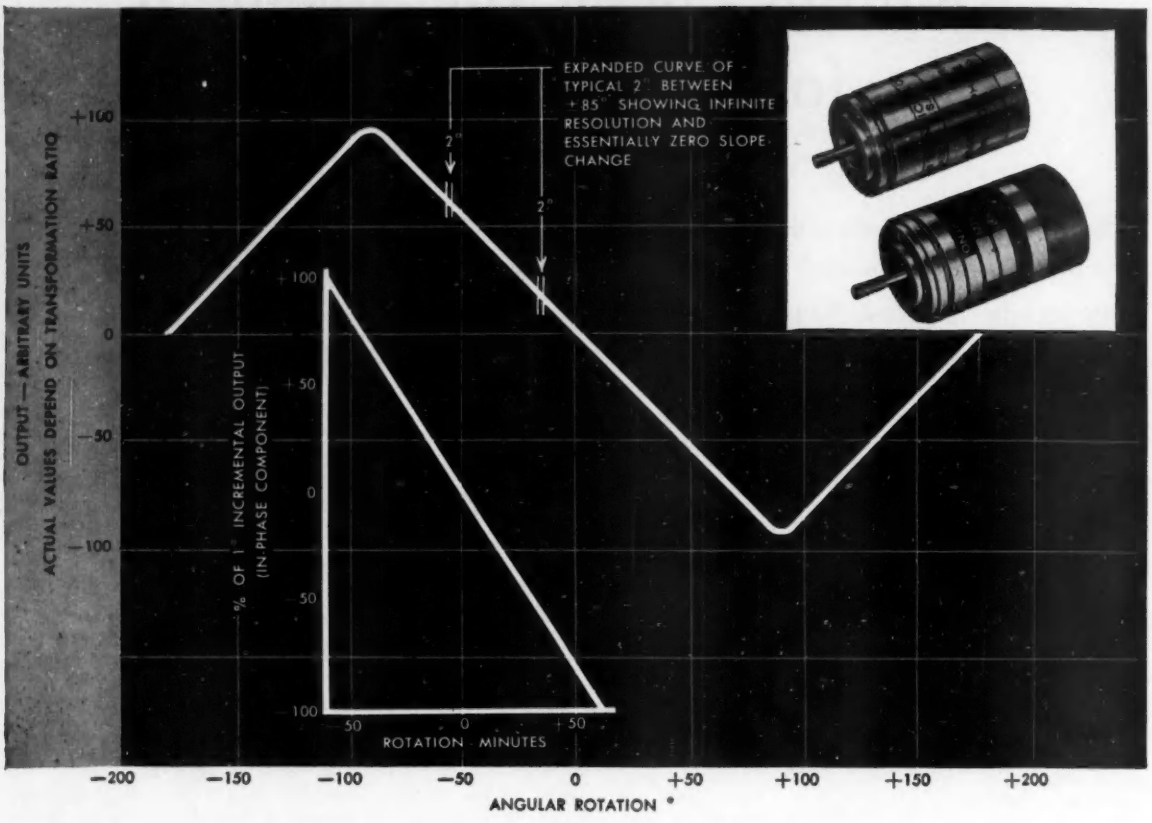


FIG. 3. Details of probe construction for 6- to 14-in. lengths.



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Write for complete specifications. Daystrom Transicoil, Division of Daystrom, Inc., Worcester, Montgomery County, Penna. Phone: JUNO 4-2421. In Canada: Daystrom, Ltd., 840 Caledonia Rd., Toronto 19, Ontario. Foreign: Daystrom International Division, 100 Empire Street, Newark 12, New Jersey.

TYPICAL CHARACTERISTICS

		Size 8		Size 11		
Volts		26	26	26	26	115
Excitation	Power (watts)	.16	.16	.15	.15	.45
	Current (ma)	27	27	30	30	24
	Frequency (cps)	400	400	400	400	400
Sensitivity (v/°)		.107	.346	.107	.346	.620
Null Volts (mv)		7	20	7	20	40
Transformation Ratio		.350	1.130	.350	1.130	.458

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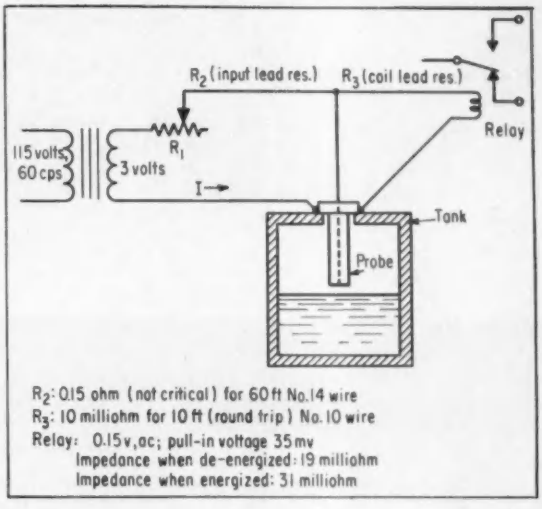
FIG. 4. Probe, and circuit used with it. Values are typical. Rheostat R_1 is used to set relay sensitivity, especially when several probes are used at once.


R2 (input lead res.)
R3 (coil lead res.)
Relay
R1
115 volts, 60 cps
3 volts
I
Tank
Probe
R2: 0.15 ohm (not critical) for 60 ft No. 14 wire
R3: 10 milliohm for 10 ft (round trip) No. 10 wire
Relay: 0.15 v, ac; pull-in voltage 35 mv
Impedance when de-energized: 19 milliohm
Impedance when energized: 31 milliohm

OPERATING DATA FOR TWO PROBES

Probe length	6-in.	14-in.
R_1—Input lead resistance	0.370 ohm	0.520 ohm
I—Input current	7.1 amp	4.2 amp
Probe resistance		
NaK below probe	15.2 milliohm	35.4 milliohm
Voltage across relay		
Level below probe	60 mv	60 mv
Level touching probe	14 mv	14 mv

the fluid contacting the probe. Figure 2 shows two models.

The probe consists of a ¼-in.-O.D., 0.025-in.-wall Inconel tube with an insulated copper conductor inside. The tip of the tube and the copper conductor are brazed to an end cap at the bottom of the tube, Figure 3. A 60-cps voltage is applied between the center electrode of the probe and the vessel in which it is installed. A sensitive relay is connected in parallel with the probe, across the center electrode and the vessel. When the fluid level is below the probe, the current path is through the center electrode and the tube wall. Since the tube wall is quite thin, a fairly high resistance path gives enough voltage to hold in the relay. Now, as the fluid touches the probe, the current path causes the voltage across the relay to decrease, allowing the relay to drop out. Note that the relay is energized with the level below the probe. This is good, since it is often desirable to have a signal when the power supply fails.

In design, reliability dictated simplicity. To get it, a single conductor probe was designed for the inside of the outside tube and insulated from it, except at the bottom end, by packed magnesium oxide insulation. The probe maintains a high ratio of tube resistance to center electrode resistance by keeping the cross section of the Inconel tube small. The value of the tube resistance and the ratio chosen depends on the relay used. For 6-in. and 14-in. probes, a ¼-in., 0.025-wall-diameter tube was chosen with a number 8 AWG copper wire for the center conductor, Figure 3. This design gives a large change in electrical resistance when NaK touches the probe end. For example, a probe extending 10 in. below the connection has the following resistances:

Temperature (deg F)	75	1,400
Inconel tube (milliohms)	24.5	25.5
Copper wire (milliohms)	0.8	3.4

Relay selection

An ac circuit was chosen in preference to a dc circuit for the following reasons:

- For a 20-millivolt dc relay, the current required per probe would be approximately 2-3 amps, giving rise to somewhat of a power supply problem if a large number of dc probes were used at different locations.
- The ratio of pull-in to drop-out voltage is high for most dc relays
- The thermal emf from the copper Inconel junction would be appreciable if highly sensitive dc relays were used.
- The reliability of very sensitive dc relays is questionable.

The ac relay used for the probe design is rated at 0.15 va, ac. It has pull-in and drop-out voltages very nearly the same—35 millivolts. When energized, it has an impedance of about 31 milliohms and when deenergized, about 19 milliohms. For level probes shorter or longer than 6-14 in., relays with different characteristics might be desirable. However, changing the tube wall thickness or using a rheostat can save the first relay.

The voltage at the probe was 3 volts, supplied by a transformer mounted away from the probe. Where a large number of probes are used, individual rheostats in each circuit adjust the probe current to give proper relay operation.

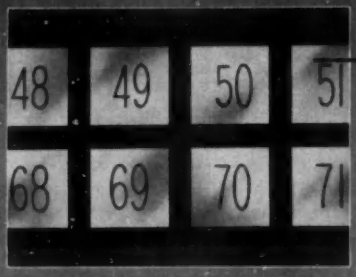
Figure 4 shows a typical installation. The resistance of the input current leads and the relay current leads should be kept as low as possible. Particular attention should be paid to the relay coil current leads because of the low impedance of the coil. It is desirable to mount the relays as close as possible to the probe; and when more than one probe is used, each should have two leads instead of a common ground.

After installation, each rheostat is adjusted to produce proper voltage, 60-65 millivolts, across each relay; no further adjustments are necessary. However, a periodic check of the relay voltage is desirable, since the relay is not a self-monitoring device.

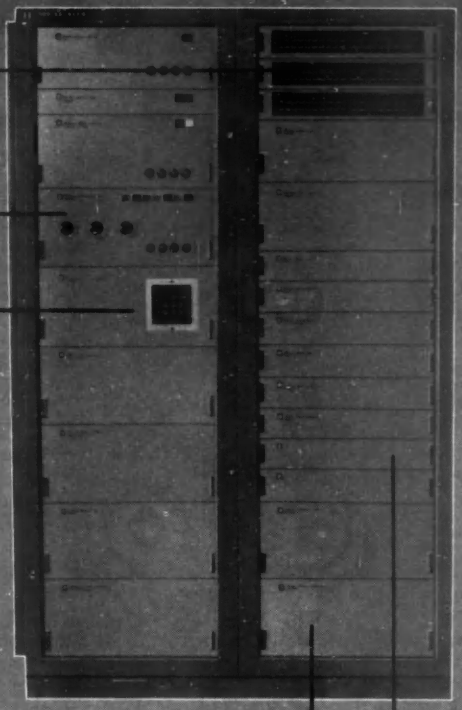
A number of probes have been built and tested. The fluids used were both Na and NaK. There is the problem of "wetting" at low-fluid temperatures due to oxide films forming on the probe and creating a large resistance between the fluid and the probe. This introduces error in the level measurement, since the level has to rise further on the probe to produce the same voltage change across the relay coil. But after a short time, or if the temperature of the fluid is above 500-600 deg F, this problem is of little consequence. The exact indication of the fluid touching the probe can be found by measuring the probe voltage with a vacuum-tube voltmeter. The only other problem encountered in using these probes is failure due to oxidation of the copper at the Inconel joint during high-temperature operation; but this will not occur if the tip of the probe is brazed with Coast Metal #52. The earlier trouble occurred when the tip was welded.

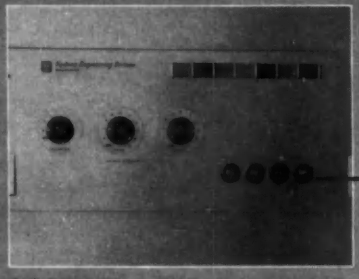
Some operating data for 6-in. and 14-in. probes are given in the table. These probes have operated for more than 3,000 hours at temperatures above 1,400 deg F without failure.

New packaged

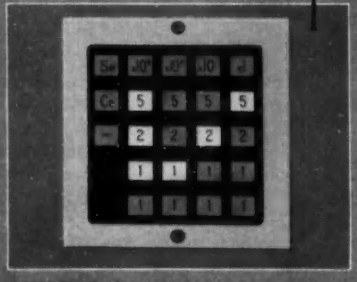


THREE 40-POINT ANNUNCIATORS make it easy for the operator to tell at a glance which variables are off-normal.

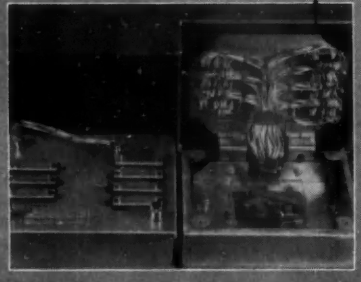




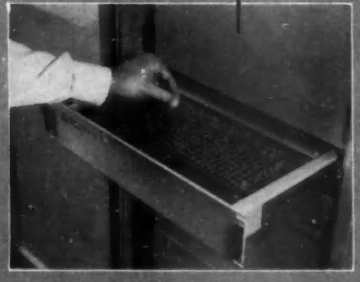
DIGITAL VISUAL DISPLAY and variable selector switches make it easy to select any single variable and watch all trends and changes continuously.



SERVICING IS SIMPLIFIED by an indicator-light panel showing the completion of each step in the analog to digital conversion. The sequence programmer can be changed from automatic to hand advance to permit operator to check each step.



UNIQUE INPUT SELECTOR is unusually dependable because of its sealed, oil-immersed construction. Servicing is normally limited to visual inspection every 6 months. Drawers pull out so voltage checks can be performed without shutting down system.



PINBOARD PROGRAMMING adds flexibility. You can change the logging or scanning sequence at will . . . substitute one type of input for another. Range, span, and zero adjustment are set by inserting pins in their proper places. No calculations are required. The pinboards are pinned in familiar units of measurements.

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The Series 3120 accepts signals from primary measuring instruments—thermocouples, flow, pressure or other transducers. It measures these signals, digitizes them, and prints their values in immediately usable form. A thermocouple reference oven can be supplied to accommodate three types of thermocouple inputs—types T, J, and K—which are automatically linearized over their entire range to within 0.1% accuracy.

The operator can select either automatically or manually initiated logging cycles. He can set the system to log all variables automatically at preset intervals, or manually energize the system to operate on demand, between logging cycles.

Between logging cycles, the system can scan off-normal alarm points—high, low or both—at a rate of 7 points per second. Upon detecting an off-normal point, the system sounds an alarm, lights a point-identification light, and prints the time, point number and off-normal value on adding machine tape. During log cycles, off-normal points are printed in red on the log sheet.

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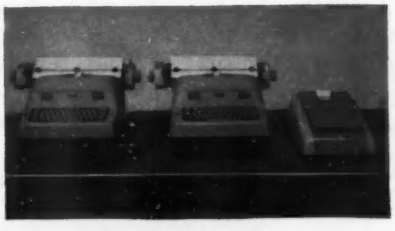

TWO TYPEWRITERS permit a single line log allowing columnar comparisons. Separate alarm printer records all off-normal variables.

STANDARD MODULAR COMPONENTS are assembled on chassis mounted as individual drawers in relay racks. All drawers are connected by plugs for easy servicing.

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6RV59

NEW PRODUCTS

REFLUX CONTROL COMPUTER—
a special product for a special purpose

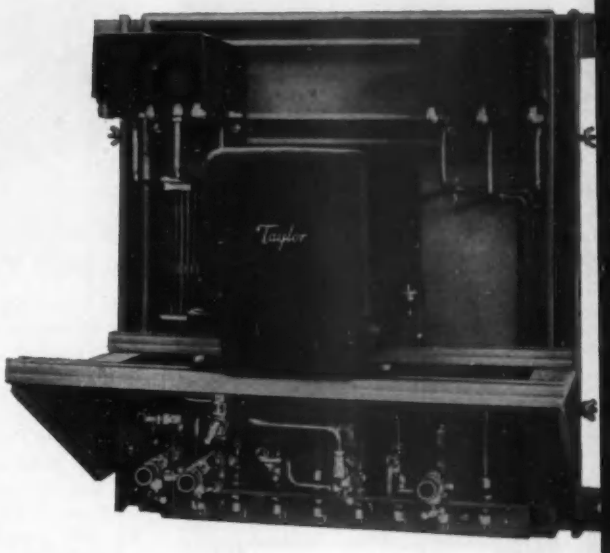
Developed under a licensing agreement with Phillips Petroleum Co., the Taylor Internal Reflux Computer Control System provides a marked improvement in the control of fractionating columns. Increased product uniformity, reduced steam consumption, and safe, continuous column operation at very near the flood point are a direct result of the system's ability to immediately compensate for disturbing climatic effects.

Heart of the system is a simple, pneumatically-operated analog computer, assembled entirely from standard instruments and components. The photo at the right, a rear view of the computer, illustrates its clean, easy-to-service design. In operation, it continuously computes internal reflux in the following equation:

$$R_i = R_e (1 + K\Delta T),$$

where R_i is the computed internal reflux; R_e, the measured external reflux; K, a constant equal to the ratio of specific heat to the heat of vaporization; and ΔT, the differential temperature between the external reflux stream and the reflux plate.

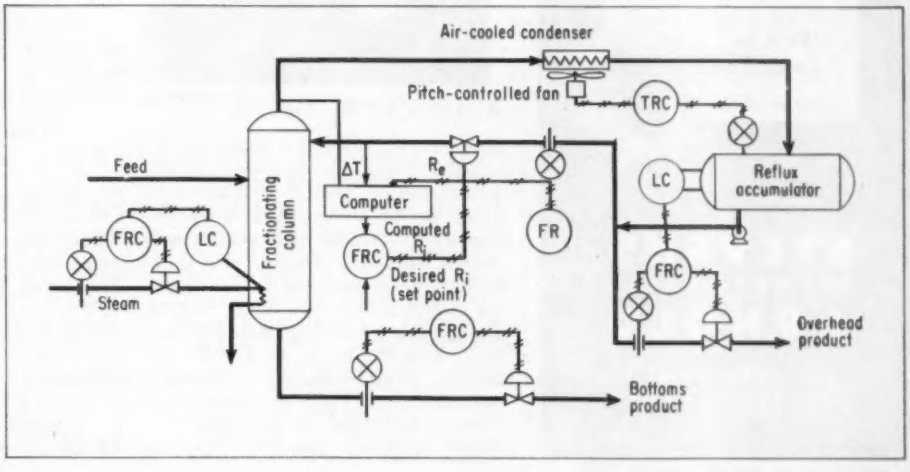
Although internal reflux seriously affects column operation, it has heretofore been an assumed value, determined principally by the external reflux. This technique, however, fails to account for such factors as changes in top plate temperature, normal day and night temperature variations, and sudden environmental changes caused by rain storms or passing clouds. All of these tend to distort any fixed ratio between internal and external reflux rates and temperatures. Thus, the use of a high-speed internal reflux computer appears to be the most efficient means yet devised to maintain a constant internal reflux rate. This is particularly true for units using air-cooled condensers.



The flow diagram below shows the relative position of the computer in the overall control system. Here, the desired rate of internal reflux is constantly present as the set point of a flow recorder-controller. The computer output, or actual rate of internal reflux, serves as the controlled variable, and is maintained by manipulating the external reflux.

At present, the system is being marketed as a complete package, including engineering, installation, and start-up.—Taylor Instrument Co., Rochester, N. Y.

Circle No. 200 on reply card



Flow diagram of a typical column with computer-controlled internal reflux

NEW
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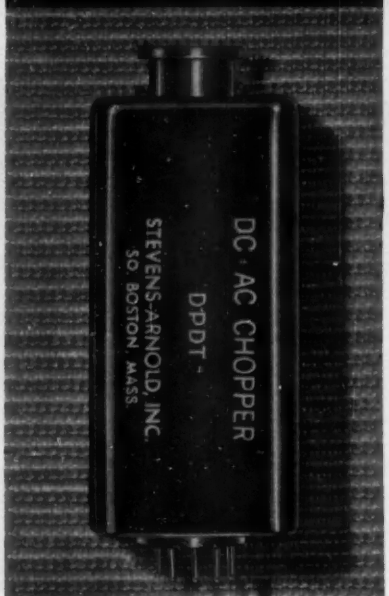
MINIATURES



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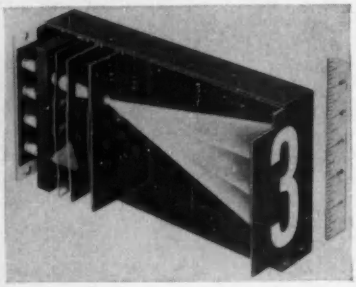
CIRCLE 82 ON READER-SERVICE CARD

DATA HANDLING & DISPLAY



LEGIBILE AT 100 FT

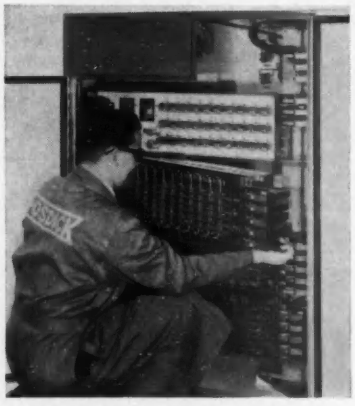
The Series 80,000 rear-projection readout for in-line digital displays provides a 3¾ in. high by 2 in. wide digit or character that can be read from over 100 ft away. Optical system features two condensing lenses and one projection lens for sharper, brighter presentation. Individual units measure 5¼ in .high, by 3¼ in. wide, by 11½ in. long and sell for $33 or less depending on quantity.—Industrial Electronic Engineers, Inc., North Hollywood, Calif.

Circle No. 201 on reply card

READS PAPER CHECKS

Every check drawn on a bank must be handled at least six times (be received, proved, sorted, posted, reviewed, and filed) before it is returned to the depositor. Deposit slips also require similar handling. To automate these tedious operations IBM has developed its Series 1200 Character Sensing Equipment. The line includes four new units: the Series 1201 Proof Inscriber, which adds the function of document inscribing to the normal proving functions of an IBM 803 Proof Machine; the 1210 Sorter-Reader, which senses magnetic-ink characters and automatically sorts up to 900 documents per min; the 1221 Sorter-Recorder Control, which directs data flow from the Sorter-Reader directly into data processing systems; and the 1202 Utility Inscriber, a special electric typewriter for inscribing unmarked, illegible, or damaged documents. Rentals for systems, including standard computers, will range from $5,000 to $40,000 per mo. First complete installation is scheduled for delivery in September, 1960.—International Business Machines Corp., White Plaines, N. Y.

Circle No. 202 on reply card



MACHINE TOOL MEMORY

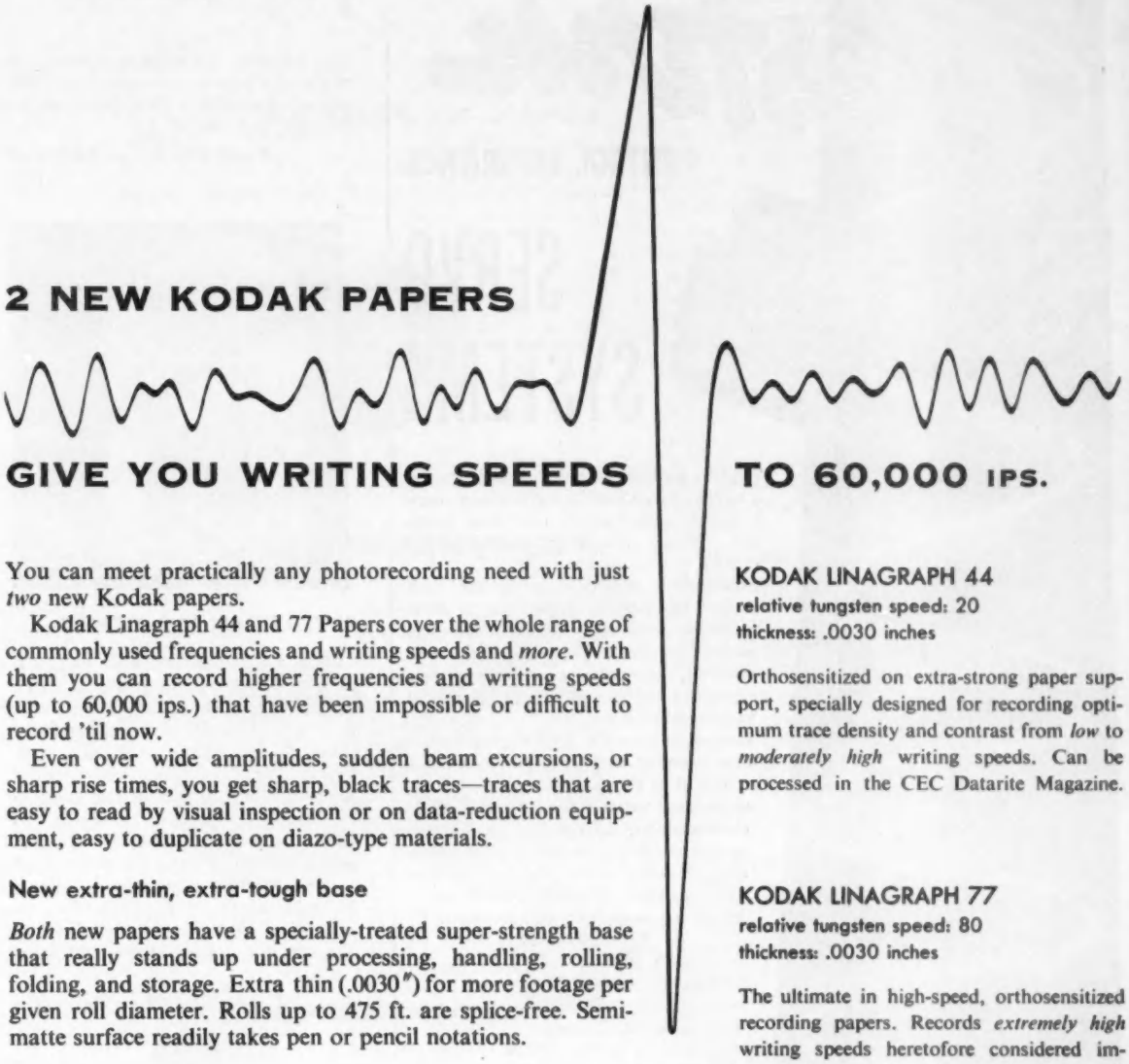
Photo above illustrates the modular design of a new plug-in memory system, developed for use in the numerical control of precision boring machines. Telephone-type crossbar switches, measuring 23 by 9 by 6 in., sealed relays, and several stepping switches satisfy all requirements; there are no electronic devices of any kind. Two crossbar switches store all the information needed to control spindle feeds and speeds, and two axes of table movement. A third can handle spindle depth control and tool designation; a fourth, automatic tool changing.—Fosdick Machine Tool Co., Cincinnati, O.

Circle No. 203 on reply card

NEW MULTI-SHIFT DESIGN

The Telecontrol data display equipment, recently introduced for centralized production control, is now available in a new multi-shift design that completely eliminates the 20-minute delay previously required for dispatchers to log the various payroll, production, and other data appearing on the panel-mounted counters. Aside from the use of dual counters, the new de-

2 NEW KODAK PAPERS



GIVE YOU WRITING SPEEDS TO 60,000 IPS.

You can meet practically any photorecording need with just *two* new Kodak papers.

Kodak Linagraph 44 and 77 Papers cover the whole range of commonly used frequencies and writing speeds and *more*. With them you can record higher frequencies and writing speeds (up to 60,000 ips.) that have been impossible or difficult to record 'til now.

Even over wide amplitudes, sudden beam excursions, or sharp rise times, you get sharp, black traces—traces that are easy to read by visual inspection or on data-reduction equipment, easy to duplicate on diazo-type materials.

New extra-thin, extra-tough base

Both new papers have a specially-treated super-strength base that really stands up under processing, handling, rolling, folding, and storage. Extra thin (.0030″) for more footage per given roll diameter. Rolls up to 475 ft. are splice-free. Semi-matte surface readily takes pen or pencil notations.

Universal processing

You can process both papers in continuous, rewind, or stabilization type equipment. After stabilization, you can handle records immediately without fear of brittleness, cracking, or tearing.

Linagraph 44 and 77 Papers are available in all standard sizes. We'd like to talk with you about your own particular application. Write for the complete technical details or, better yet, ask for a demonstration by our Technical Representative in your area.

KODAK LINAGRAPH 44

relative tungsten speed: 20
thickness: .0030 inches

Orthosensitized on extra-strong paper support, specially designed for recording optimum trace density and contrast from *low* to *moderately high* writing speeds. Can be processed in the CEC Datarite Magazine.

KODAK LINAGRAPH 77

relative tungsten speed: 80
thickness: .0030 inches

The ultimate in high-speed, orthosensitized recording papers. Records *extremely high* writing speeds heretofore considered impractical, yet still retains good trace densities. Covers writing speeds up to 60,000 ips. Because of its wide exposure latitude it records medium-speed traces as well, with excellent clarity. On specially-made rugged, durable paper stock.

EASTMAN KODAK COMPANY, Rochester 4, N. Y.
Photo Recording Methods Division

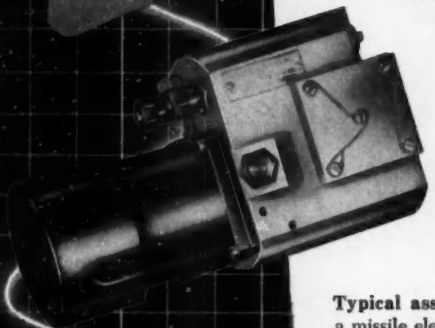
Kodak
TRADE MARK

BUILD ON...

Eastern

CONTROL EXPERIENCE:

SERVO SYSTEMS



Typical assignment: design and develop a missile elevon control servo with a single hydraulic power supply and three actuators. Weight and space considerations critical.

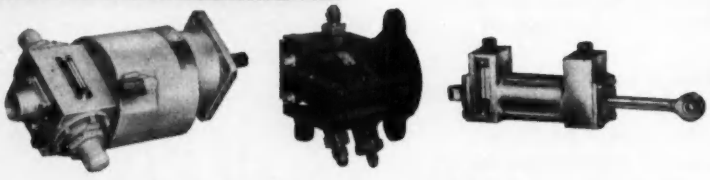
Solution: a system designed and built around the Eastern E/HS 5 type 100A hydraulic power supply, using a 400-cycle motor. Minus motor, but including pump, reservoir, expansion chamber, pressure regulating valve and filter, the supply weighs only 2.6 lbs.

Eastern achieved a 20% saving in hydraulic power supply capacity by the use of one of its own *pulse length modulated* single-stage servo valves, manifolded to each actuator. Zero first stage leakage, zero hysteresis, plus the high response and efficiency which characterize this valve contributed to the successful meeting of the demanding requirements.

Specifications:

force level: 300 lbs.
total stroke: 1/2 in.
max. velocity: 1.5 in./sec.
time constant: 0.1 sec.
max. actuator width: 1.25 in.

For genuine contributions to the solution of your servo problems, call in the Eastern engineer.



servo-valves • fuel controls • actuators

EASTERN INDUSTRIES INCORPORATED
100 SKIFF STREET
HAMDEN 14, CONN.

Eastern AVIATION PRODUCTS

CIRCLE 84 ON READER-SERVICE CARD

NEW PRODUCTS

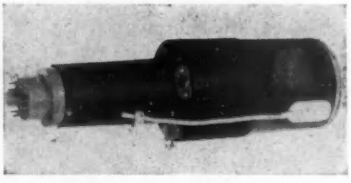
sign involves the same equipment as the earlier version and costs very little more.—Telecontrol Div., Hancock Industries, Jackson, Mich.

Circle No. 204 on reply card

SAVES SPACE AND MONEY

Called a Quadratron, this compact, plug-in computing unit is said to be capable of replacing a system more than 700 times its size, costing thousands of dollars more. Analog computers, control systems, and medical electronics are typical of the areas in which the device may be applied to advantage. Specifically, the Quadratron can provide some 25 of the most commonly used nonlinear functions, including algebraic, trigonometric, exponential, and hyperbolic.—Douglas Aircraft Co., Inc., Santa Monica, Calif.

Circle No. 205 on reply card



LOW DISTORTION

Registered as EIA Type 5 BFP, this new dual-beam, fast-writing CR tube is particularly well suited for high altitude operation. Linear post acceleration minimizes pattern distortion of its two independently controlled beams. Features include a flat face plate, an integral mu-metal shield, and an aluminized screen. Operating voltages are 13,250v for the post accelerator, 2,750v for the accelerator, and

USE LOTS OF TAPE?

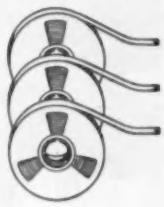
"SCOTCH" BRAND Instrumentation Tapes cut operating costs

Let's develop our own small theory of relativity. For everything's relative, after all—even economy. Clearly, an economy effected now and *corrected* later is no economy at all. In instrumentation tape, there's only one genuine economy—reliable performance. And in performance, the last two words for any acute tape-user are "SCOTCH" BRAND.

First to last, "SCOTCH" BRAND Magnetic Tapes offer uniformity and reliability—born of the experienced 3M technology that created the first practical magnetic tape and continues to advance the art of tape-making day by day.

But let's look at economy from another viewpoint—in terms of some things around the periphery that might not come so readily to mind—storage, use, waste, and time saved.

What other kind of record is so permanent it may last a lifetime, yet requires so little space for storage? Three reels of "SCOTCH" BRAND like those at the right "contain" 30 million characters. What other medium serves input, output and memory functions at such high speeds? Accepts both digital and analogue data?



What other kind of record is not *consumed*, even when it is used? "SCOTCH" BRAND Magnetic Tape is run and rerun for analysis, erased and used again, permits retaping with corrections, editing and new data.

Last, but far from least—in these days when time is money, what other medium speeds up data acquisition, reduction and control programming in a way that keeps critical projects rushing forward at full tilt? Or cuts production lead time and human error to a point where a 1000% saving may be realized?

At any cost, "SCOTCH" BRAND Magnetic Tapes would be a good buy. And in every application, "SCOTCH" BRAND Tapes offer that greater economy—reliability. "SCOTCH" BRAND High Resolution Tapes 158 and 159 let you pack more bits per inch, offer extra play reels. "SCOTCH" BRAND Sandwich Tapes 188 and 189 end rub-off, build-up, cut head wear to an absolute minimum, show little wear in 50,000 computer passes. "SCOTCH" BRAND High Output Tape 128 offers top output at low frequencies, even under ambient temperature extremes. "SCOTCH" BRAND Instrumentation Tapes 108 and 109 offer top performance at lowest cost.

Where there's no margin for error, there's no tape like "SCOTCH" BRAND Magnetic Instrumentation Tape. For details, write Magnetic Products Div., 3M Company, Dept. MBS-79, St. Paul 6, Minn., or mail the reader inquiry card. © 1959 3M Co.

"SCOTCH" is a registered trademark of 3M Company, St. Paul 6, Minnesota. Export: 99 Park Avenue, New York, N.Y. In Canada: London, Ontario.

SCOTCH BRAND MAGNETIC TAPE
FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

WILL THE TAPE RECORDER YOU BUY HAVE MAGAZINE LOADING?

Installing the magazine on the PS-200. Complete magazine change requires only 5 seconds.

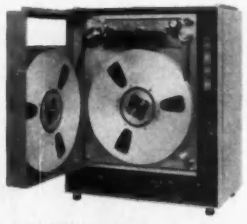
PLUS

* Transistorized electronics
* Up to 14 channels of record/reproduce
* Modular card construction
* End of tape sensing
* Light weight – only 65 lbs.
* Tape speeds 1⅞ to 60 ips

PS-200 FEATURES UNIQUE STACKED-REEL MAGAZINE.
Using 10½" standard NARTB or commercially available precision reels, the magazine is designed so that it can be completely removed from the transport or opened while still attached to the machine. No additional threading is required to change magazines. The magazine automatically locks in place, ready for operation with only five seconds interruption. Tape is in contact with heads in drive mode only. Head wear and oxide deposit are reduced.
The PS-200 can be quickly converted to a loop transport by simply exchanging the reel-to-reel magazine for a loop magazine.

The PS-200 instrumentation magnetic tape recorder combines transistorized electronics with a stacked reel tape magazine. Result – 10 to 1 weight, size, and power reduction with no degradation in flexibility or performance. Recording characteristics, tape speeds, and all other parameters of the PS-200 are completely compatible with standard recording practices.

Twenty-eight sales engineering representative offices are located throughout the United States and Canada to assist you with your data recording problems. For his name and free copy of new 8-page brochure, please write, call or wire Dept. C7.



Model PS-200 with magazine open. Note stacked reel construction.

PRECISION INSTRUMENT COMPANY
1011 COMMERCIAL STREET, SAN CARLOS, CALIFORNIA • PHONE: LYTELL 1-4441

CIRCLE 86 ON READER-SERVICE CARD

NEW PRODUCTS

600 to 900 v for the focusing electrode.–Allen B. Du Mont Laboratories, Inc., Clifton, N. J.

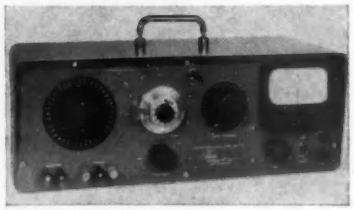
Circle No. 206 on reply card

HIGH-SPEED CARD SORTER

Manufacturer claims that the new IBM 84 punched-card sorter operates at a speed of 2,000 cards per min, or twice as fast as its fastest predecessor. Significant features of the new sorter include: transistorized circuits; built-in, vacuum-assist card feeding; photo-sensing; radial stacking; and continuous loading. Its file feed has a capacity of 3,600 cards; each sorter pocket, a 1,650-card capacity. Dynamic braking stops the machine whenever a stop is called for.–International Business Machine Corp., White Plains, N. Y.

Circle No. 207 on reply card

RESEARCH, TEST & DEVELOPMENT

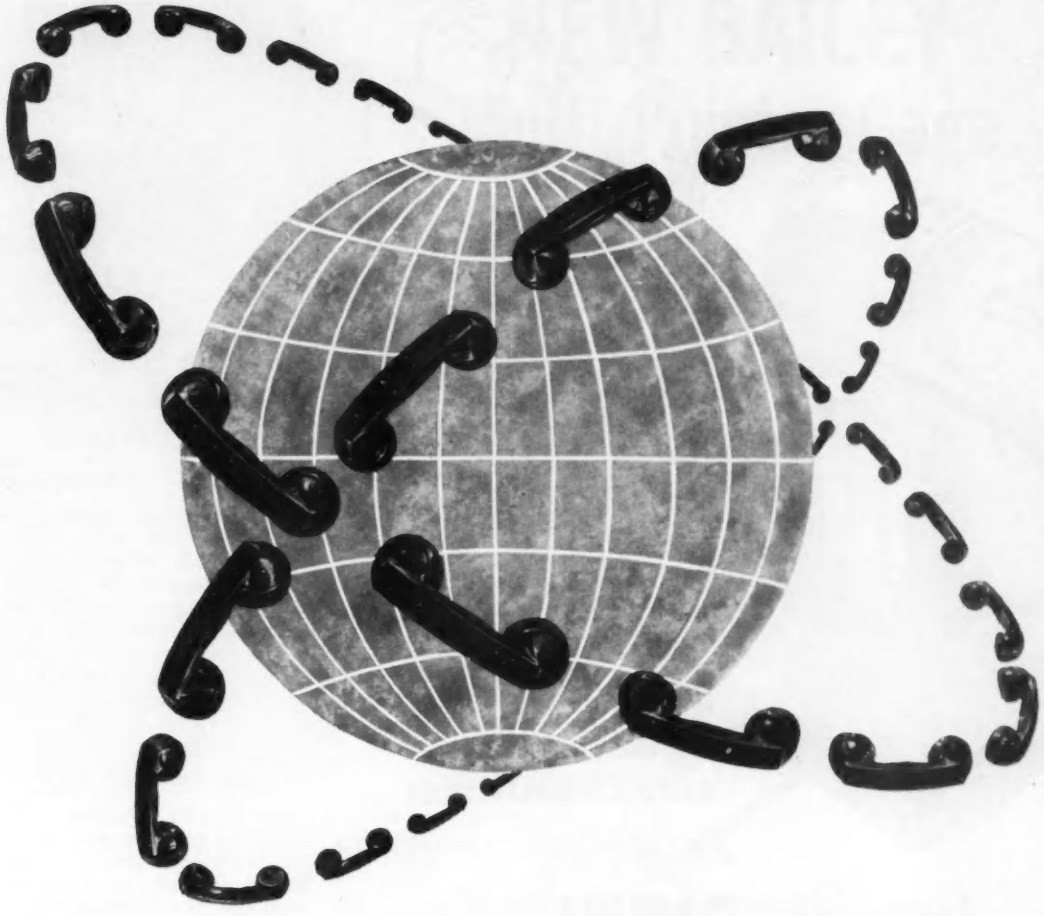


NEW ERROR BRIDGE

With this new Theta Bridge, angular position of any inaccessible synchro or resolver can be measured directly without mechanical coupling. Connection is through the leads of the instrument being measured. High impedance elements in the bridge prevent loading of the system. The bridge also serves as a simulator of a perfect synchro or resolver input for system study. Three dials display angular position to three decimal places.

Characteristics:
Range: 360 deg
Readability: within 3.6 sec
Accuracy: within 10 sec
Operating frequency: 400 cps
Impedance: 10,000 ohms, each leg
–Theta Instrument Corp., East Paterson, N. J.

Circle No. 208 on reply card



Tomorrow's dialing will be out of this world

Global telephone calls via satellites brought nearer by a new ITT electron tube

From the nation-wide resources of ITT Laboratories has come the ultimate development in a unique electronic amplifying device called the *traveling wave tube.*

A four-foot version pioneered by ITT for the Armed Forces can transmit as many as 100,000 telephone messages *simultaneously!*

Telephone Exchanges in the Sky

Now a miniaturized type is to be produced by ITT Components Division—small enough for satellites, where its amazing message capacity could be utilized to relay *thousands* of dial telephone calls to points around the globe.

ITT traveling wave tubes of many sizes are already in use in major areas of telecommunications, and in radar, missile guidance, electronic countermeasures, microwave radio, and television.

Pioneers in Electron Tubes

ITT Components Division, backed by experience almost as old as the electron tube industry itself, also manufactures *Iatron*® tubes that can display information, store it for days, erase it at will; photo multiplier tubes that convert light into an electrical signal and amplify it millions of times; image converter tubes for infrared applications, and tubes that give sharp eyes to our radar warning systems.

Other ITT tubes include types for industrial power, rectification, and radio-TV broadcast transmission.

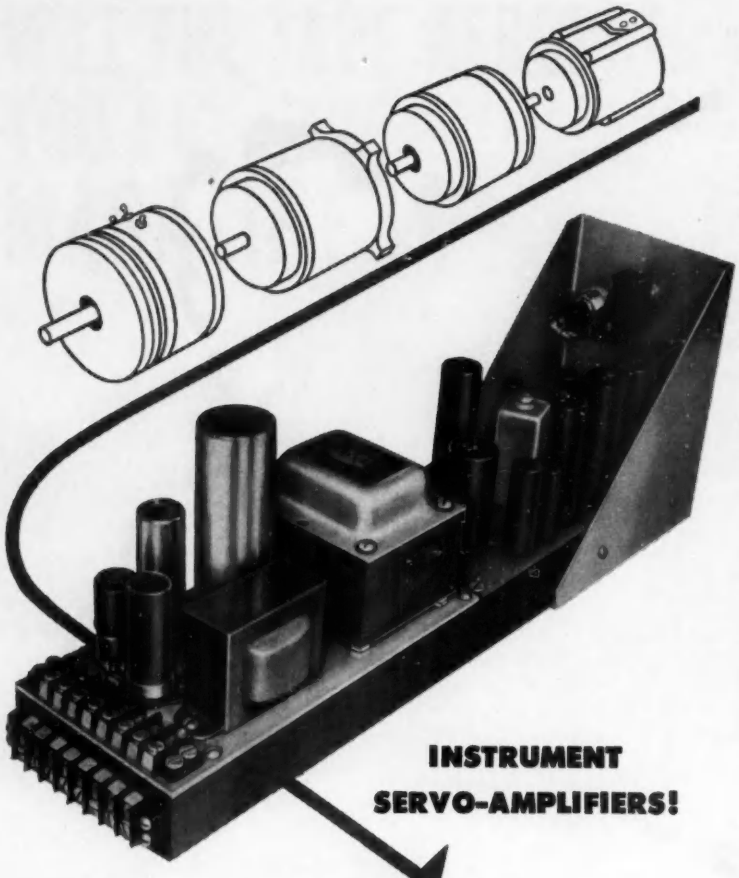
In the free world today, nine ITT System companies are developing and building electron tubes for hundreds of essential and sophisticated tasks—in laboratories, industry, global communications, and national defense. For information, write ITT Components Division, Clifton, New Jersey.

ITT

. . . the largest American-owned world-wide electronic and telecommunication enterprise, with 101 research and manufacturing units, 14 operating companies and 130,000 employees.

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION 67 Broad Street, New York 4, N. Y.

ITT COMPONENTS DIVISION • ITT FEDERAL DIVISION • ITT INDUSTRIAL PRODUCTS DIVISION • ITT LABORATORIES • INTELEX SYSTEMS INCORPORATED AIRMATIC SYSTEMS CORPORATION • KELLOGG SWITCHBOARD AND SUPPLY COMPANY • ROYAL ELECTRIC CORPORATION • AMERICAN CABLE & RADIO CORPORATION • FEDERAL ELECTRIC CORPORATION • ITT COMMUNICATION SYSTEMS, INC. • INTERNATIONAL ELECTRIC CORPORATION • INTERNATIONAL STANDARD ELECTRIC CORPORATION • LABORATORIES AND MANUFACTURING PLANTS IN 20 FREE-WORLD COUNTRIES



an addition to the DIEHL* family of
INSTRUMENT SERVO COMPONENTS

This new line of Instrument Servo-Amplifiers, coupled to an already established family of DIEHL Instrument Servomotors, Tachometers and Gear Reducers, further expands the new DIEHL concept of furnishing high quality servo components in modular form.

These units have been designed so that a true servomotor-amplifier combination featuring faster SERVO response is at last available from a single source of supply.

DIEHL Instrument Servo-Amplifiers are supplied in ratings suitable for driving the popular 1, 5 and 10 watt motors and use printed circuitry for high reliability.

FEATURES

- Standard rack mounting.
- Control adjustments for gain, phase, internal feedback, and external feedback.
- Push-pull output stage matched to motor control phase.
- A.C. or D.C. input.
- With or without integral power supply.
- Reliable, premium quality vacuum tubes.

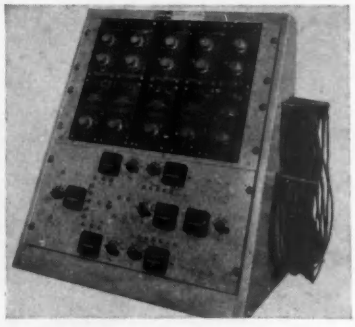
Write for detailed information on this complete line of Instrument Servo Components.

DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.
other available components
• AC SERVOMOTORS • AC SERVOMOTORS WITH AC TACHOMETERS • DC SERVO SETS
• AC SERVOMOTORS WITH DC TACHOMETERS • AC AND DC TACHOMETERS • RESOLVERS

*A Trademark of DIEHL MANUFACTURING COMPANY †A Trademark of THE SINGER MANUFACTURING COMPANY

CIRCLE 88 ON READER-SERVICE CARD

NEW PRODUCTS



TRANSISTOR BREADBOARD

Rapid evaluation of transistor characteristics in various circuit designs can be made on this Model TB-1 electronic breadboard. Six resistance and four capacitance substitution boxes nest in the upper half of the unit and may be arranged so as to closely resemble the schematic layout of the test circuit. Resistance values range from 15 ohms to 10 megohm; capacitance values, from 0.0001 to 0.22 fd. Seven small precision meters permit all current and voltage readings to be made without switching. Jumper leads, box terminals and meter terminals are equipped with snap-on connectors for fast set-up—Abrams Instrument Corp., Lansing, Mich.

Circle No. 209 on reply card

COMPUTER CHECK PANEL

New preventive maintenance check panels provide a convenient means of verifying the accuracy of fully-expanded 16-31R and 16-131R PACE analog computing systems and other smaller or nonstandard systems. Units are permanently wired with control and selector switches that permit sequential testing of all major computing elements. With proper use, the panels should reduce unnecessary trouble-shooting and minimize downtime. Checks ca nbe made in the middle of a problem without disturbing the problem set-up.—Electronic Associates, Inc., Long Branch, N. J.

Circle No. 210 on reply card

SIMPLIFIES ANALYSIS

Developed for use with L&N's Electro-Chemograph, the new Polarotron dropping-mercury electrode contains a stable half-cell which enables the test vessel to be rotated for quick change of

NEW BAILEY
Multi-Pointer Gage

...has twice as many indicators
...no taller than a telephone!

Now the popular versatile Bailey Multi-Pointer Gage has been reduced in size to conserve control panel space—without loss of easy *readability*.

Each new Multi-Pointer Gage Unit offers you these three choices to—

1. Measure and indicate draft, pressure, differential pressure and level.
2. Transmit above variables either pneumatically or electrically to remote indicators, recorders and/or controllers.
3. Receive and indicate any measured variables which may be transmitted pneumatically by standard SAMA ranges of 3-15 psig. or 3-27 psig.

FEATURES

Compact Size—Two large, easily-read 7″ scales in space only 4 inches wide.

Wide Range Selection—Standard ranges from 0-0.5 in. H_2O to 0-5000 psig available.

Choice of Standard Colors—Satin Black, Slate Gray, Moss Green, or Terra Tan may be selected as an exterior color at no additional cost.

Colored Scales—Scales available in white, red, green, blue, yellow, or orange.

Fluorescent Illumination—All gages have slideout unit containing bulb and starter for ease of maintenance.

Readily Accessible Adjustments—Zero adjustment made from front of gage. Other adjustments made from rear of gage.

Two-point Positive Mounting—Gage unit mounted with two clips . . . no holes to drill or studs to weld.

Unlimited Indications—Any number of basic two-indicator units may be placed side-by-side to provide indications of related factors. Each two-indicator unit is separately mounted.

For additional information, call your local Bailey District Office, or write us direct. G47-1

Instruments and controls for power and process

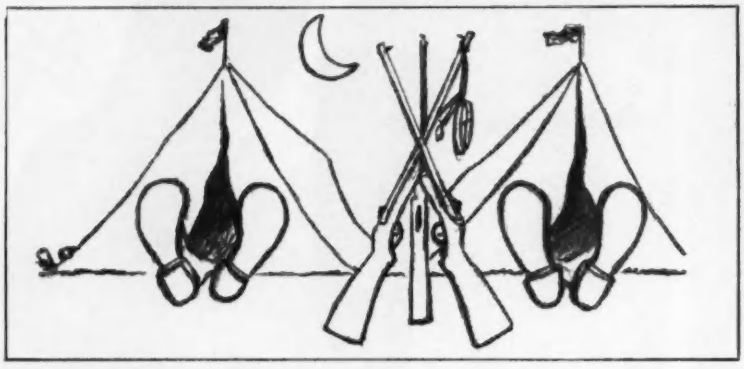
BAILEY METER COMPANY

1079 IVANHOE ROAD *CLEVELAND 10, OHIO*

In Canada—Bailey Meter Company Limited, Montreal

CIRCLE 89 ON READER-SERVICE CARD

SIGMA RELAY FOR MILITARY EQUIPMENT NOW TWICE AS SENSITIVE; DESIGNERS GET TWO WEEKS OFF



Sensitive relays* have very little company these days, as they continue to do the same job they always have, but on less and less take-home power. There was a time when you could say a relay was sensitive if it would operate around 50 milliwatts or so; now, it has to do the same work on about half as much coil power. Alas, the price of Progress she comes high . . .

With this philosophy firmly implanted, our Chief Sensitivity Engineers took a perfectly good "military" Sigma relay of fairly wide application success and attempted to make it more sensitive, without impairing any of its other characteristics. The fruits of their labors is a new adjustment which is twice as sensitive as the original relay, since the required operate power is only half as much as the old style which is also still available if you've got double the number of milliwatts to play with as anyone else currently building military gear.

With the sensitivity question all straightened out, these two Chiefs were given their just reward and flown by privately chartered aircraft to a secluded spot for the vacation they so richly deserved. Found among the papers they left behind were the following additional facts, which may be of interest to anyone who has to squeeze an SPDT or DPDT relay into 1.75 cubic inches and have it work on next to nothing, in airborne and similar environments.

*(unlike other people)

SERIES 22 — "S" ADJUSTMENT

SENSITIVITY	12 mw. SPDT, 20 mw. DPDT
CONTACT RATING	up to 2 amp. (28VDC/120VAC)
OPERATING TEMP.	−65°C. to +125°C.
VIBRATION	10 g to 300 cps
SHOCK	100 g will not cause damage
ENCLOSURE	hermetic seal

(Other adjustments of the "22" have similar ratings, except for sensitivity which is 20 and 40 mw.)

Series 22 bulletin on request, but you may have to wait a little while until everyone gets back to work—annual plant shutdown takes place the first two weeks of July.

SIGMA

SIGMA INSTRUMENTS, INC.
69 Pearl Street, So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1930)

CIRCLE 90 ON READER-SERVICE CARD

sample solution. The unit combines, in a single package, the dropping-mercury system, constant-head mercury column, test vessel, reference electrode, reference saltbridge, water bath, and gas flowmeter, and eliminates the problem of setting-up, operating, and maintaining the ordinary glass polarizing cell. Ideal for applications requiring repetitive analyses, it may be used with metals, organics, or biochemicals.—Leeds & Northrup Co., Philadelphia, Pa.

Circle No. 211 on reply card

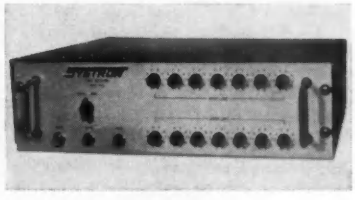
ANGLE INDICATOR

Designed for laboratory, production, or field work, this compact instrument consist of a precise angle indicator, motor, and servo amplifier. The standard model, equipped for use with a 26-v synchro transmitter, can be modified to user's specifications.

Characteristics:

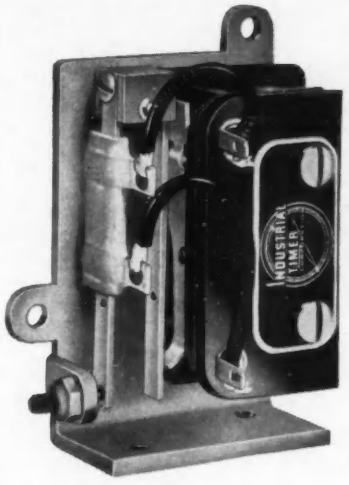
Repeatability: within 0.6 min
Readability: 0.5 min, 0-360 deg
Accuracy: within 6 min
Input: 115v, 400 cps, 1-phase
—Kearfott Co., Inc., Clifton, N. J.

Circle No. 212 on reply card



LIMIT DETECTOR

Two banks of presettable switches establish upper and lower limits in this new Model 1740 Digital Limit Detector. Front-panel lights indicate "high", "within", or "low", as the unit monitors each cycle of a digital counter. Contact-closure outputs provide classification or control for each



These new developments are just two recent items added to our ever growing line of industrial timing devices which now exceeds 1,700 controls. If you would like more information about the line, drop us a note requesting our general catalogue.

NEW! MINIATURE THERMAL TIME DELAY SWITCH

10-20 Amp. Capacity—SNAP ACTION

The new Series TH Timer makes accurate switching control of high current applications *practical* and *economical* for the first time! No more bulky, costly thermal switch and relay combinations . . . no more teasing of load contacts in electro-mechanical circuits from slow make-and-break. The new Series TH Timer's SNAP ACTION contacts give *fast, positive* switching of loads *up to 20 amperes.*

There's a wide choice of contacts, too: SPDT, DPDT, Double Break, Magnetic Blowout DC and others to match your needs.

This new, compact timer automatically compensates for ambient temperature changes, by using two parallel bi-metal strips. Longer life comes from the rugged, totally enclosed cast ceramic heater. And you can adjust your time cycle easily with a single screw.

Available in time cycles from 15 seconds to 2 minutes, the new Series TH Timers are the low-cost answer to switching in air conditioning, refrigeration, exhaust and heater controls, computers, lighting, and a host of other applications.

For complete information, write today for Bulletin #900.

NEW! SIMPLIFIED PUNCHED CARD PROGRAMMER

Direct Control from Programmer to Process!

Here's the simple, dependable method of applying true automatic control to most of your manufacturing and operational processes . . . *direct control* of up to 85 individual load circuits through as many as 30 separate functions . . . with permanent, convenient 5″ x 9″ Mylar* punched cards.

Operation from any switch closure makes this electro-mechanical card reader easily adaptable to a variety of control systems, including analog, digital, temperature, feed-back, photoelectric, time and many others. Already in use for a wide variety of industrial and military applications, these flexible units are easily modified to meet your particular requirement.

For more information, write for Bulletin #100.

AFFILIATE—LINE ELECTRIC COMPANY

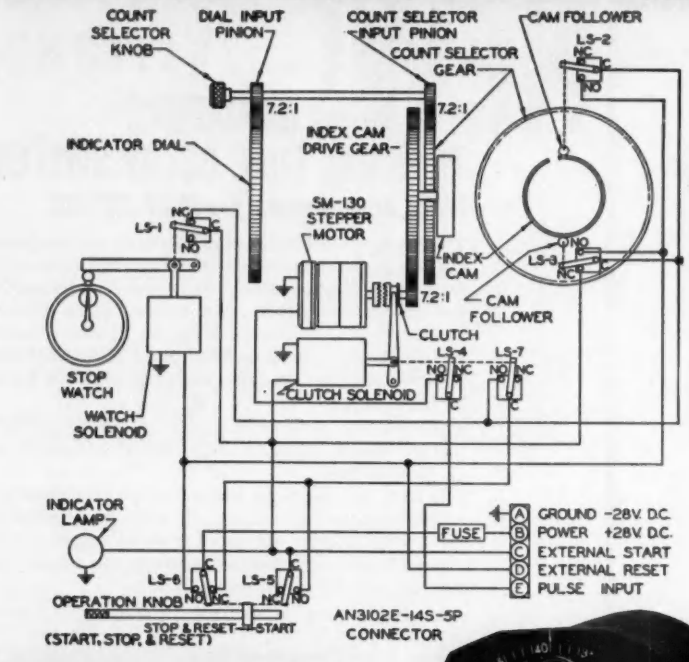
*Reg. T.M. du Pont

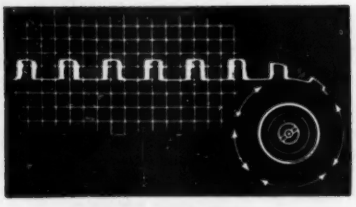
Timers that Control the Pulse Beat of Industry

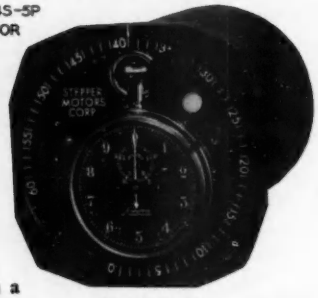
INDUSTRIAL TIMER CORPORATION

1419 McCARTER HIGHWAY, NEWARK 4, N. J.

STEPPER AUTOMATIC PULSE TIMER







Model K-165

This Automatic Pulse Timer mounts in a standard 3⅛" mounting. The initial usage of the Automatic Pulse Timer was for a difficult instrumentation problem encountered on test aircraft—timing the pulses from a fuel flow transducer and thus determining specific fuel consumption. It successfully replaced a complex and unreliable method.

The Automatic Pulse Timer incorporates an uni-directional Stepper Motor along with complimentary gears, cams, solenoids, switches, an indicator light and—for an accurate independent time base—a stop watch. It is designed to visually record the lapsed time of an occurance of a specific number of electrical impulses. The Pulse Timer can count pre-selected quantity of 2 to 60 pulses, having a uniform or variable rate up to 25 pulses per second.

In this application the combined accuracy of the fuel flow transmitter and the automatic pulse timer is better than 1%, and of this the timer contributes essentially no error. When the broad input requirements are available, the unit can be used for timing pulses regardless of the source from which they may originate.

DETAILED OPERATIONAL SEQUENCE IS AVAILABLE UPON REQUEST.

STEPPER MOTORS CORPORATION

Subsidiary of California Eastern Aviation, Inc.

7442 West Wilson Avenue • Chicago 31, Illinois

• WEST COAST . . . 1732 W. SLAUSON AVE., LOS ANGELES 47, CALIF.

CIRCLE 92 ON READER-SERVICE CARD

NEW PRODUCTS

of these conditions. Limits may contain from one to 10 digits (model shown has seven).—Systron Corp., Concord, Calif.

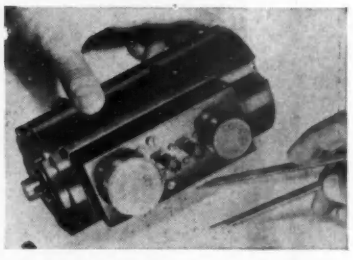
Circle No. 213 on reply card

PLUS . . .

(214) A portable ac- or battery-operated **checkout system** for confidence level tests on air traffic control beacons has just been announced by **Packard Bell Electronics Corp.**, Los Angeles, Calif. . . . (215) **Potential, Inc.**, Solana Beach, Calif., now offers the Model 201 **Functional Multiplier**, a lab instrument capable of instantaneous, four-quadrant multiplication of two electronic signals. . . . (216) Main features of the M-24 **Digital Volt-OHM-Ratiometer**, a product of **Non-Linear Systems, Inc.**, Del Mar, Calif., is its 0.1-mv and 0.1-ohm sensitivity. . . . (217) **Ohio Semiconductors, Inc.**, Columbus, O., has started pilot production of its Type TA-11 Thermocell, a **thermoelectric junction** that will produce a temperature differential of 40 deg C with an input power of 2 watts.

Circle No. 214, 215, 216 217 on reply card

PRIMARY ELEMENTS & TRANSDUCERS



3.6 SEC ACCURACY

Pictured here is the transducer used in a new electromechanical angle encoding system, designed to provide a continuous digital display of shaft angle, and capable of resolving 1,000 parts per deg. Within the transducer, a code disc resolves integral degrees and provides a binary-coded decimal signal to a code translator for direct

REPORT FROM **ARMA**

The Missile Train—Mobile Sunday Punch

In the foreground above is the missile train—a hit-and-run Sunday punch for our modern Army. In event of war, the train could fire a missile with nuclear warhead, move rapidly miles away, then fire other missiles . . . without becoming a vulnerable stationary target itself. The missile train would be an ever-present threat to the enemy's tactical units over a wide area.

For such imaginative projects as the missile train, which combines maximum mobility with maximum firepower, ARMA has developed an equally imaginative universal navigation system. Not only can ARMA systems rapidly locate and aim all types of Army missiles, but they are applicable to all types of land, sea and air operations. To the Army, ARMA offers precise vehicular navigation systems for use in artillery and missile survey, combat vehicles, tanks, and helicopters as well as remote control types for mine detection and atomic blast survey. Precision navigation systems are ARMA's business from ships to ICBM's and—beyond.

ARMA, Garden City, N. Y., a division of American Bosch Arma Corp. . . . the future is our business.

6866

AMERICAN BOSCH ARMA CORPORATION

CIRCLE 93 ON READER-SERVICE CARD

Specify the

T-J Spacemaker

for longer, more efficient cylinder service

You too—can reduce replacement expenditures—lower maintenance costs with the T-J Spacemaker cylinder line. Designed and engineered for ruggedness, and accuracy of operation, the Spacemaker assures longer, uninterrupted operation.

The T-J Spacemaker eliminates tie-rods, gives greater strength, saves space . . . and reduces costs in all push-pull operations. Immediate delivery in a complete range of styles and capacities . . . air or oil. Write for Bulletin SM 155-4, today. The Tomkins-Johnson Company, Jackson, Michigan.

WITH EXTRAS . . . AT NO EXTRA COST

1. METAL PISTON ROD SCRAPER—protects rod packing, cylinder bore and rod surface by removing all foreign particles.
2. NEW "SUPER" CUSHION for air or METALLIC SELF-ALIGNING MASTER CUSHION for oil.
3. HARD CHROME PLATED CYLINDER BORES AND PISTON RODS for greater protection and reduced wear.
4. ONE PIECE PISTON assures better alignment, longer bearing and packing life.
5. FORGED SOLID STEEL HEADS throughout entire line.
6. PILOTED PACKING GLAND with extra long bearing for additional strength and support to piston rod.
7. NO TIE-RODS TO STRETCH—gives you 360° port rotation . . . less space used . . . full strength.
8. STREAMLINED DESIGN . . . operating pressures to 200 PSI, air; 1,000 PSI oil, non-shock.

T-J TOMKINS-JOHNSON
RIVITORS . . AIR AND HYDRAULIC CYLINDERS . . CUTTERS . . CLINCHORS

CIRCLE 94 ON READER-SERVICE CARD

digital display. Vernier section of the transducer contains a reference stator (fixed), a variable stator (attached to the input shaft), and a 900 rpm rotor. Both stators generate 5.4-Kc tones but any displacement of the input shaft causes a phase shift between these tones. For every 0.001 deg rotation of the input shaft, an "add" or subtract" pulse (depending on direction of rotation) is sent to a counter. This counter provides the "thousandths", or last three digits in the Nixie display.—Norden Div., United Aircraft Corp., Milford, Conn.

Circle No. 218 on reply card

EXTREMELY SENSITIVE

Available in Sizes 10 and 22, two new non-pendulous single-axis accelerometers feature threshold sensitivities of 10^{-4} and 10^{-5} g. Both are ruggedly constructed, cover a range of plus or minus 10g's, and use a spring mass system that is completely insensitive to accelerations normal to their input axes. Built to operate in high-vibration environments, the units are ideal for missile inertial guidance applications. Other characteristics of the Size 10 model include a calibration drift within 0.15 percent per mo, a linearity within 0.25 percent, and an overall weight of 1.5 oz. Comparable specs on the Size 22 are as follows: calibration drift, 0.05 percent per mo; linearity, within 0.02 percent; weight, 8 oz.—Kearfott Co., Inc., Clifton, N. J.

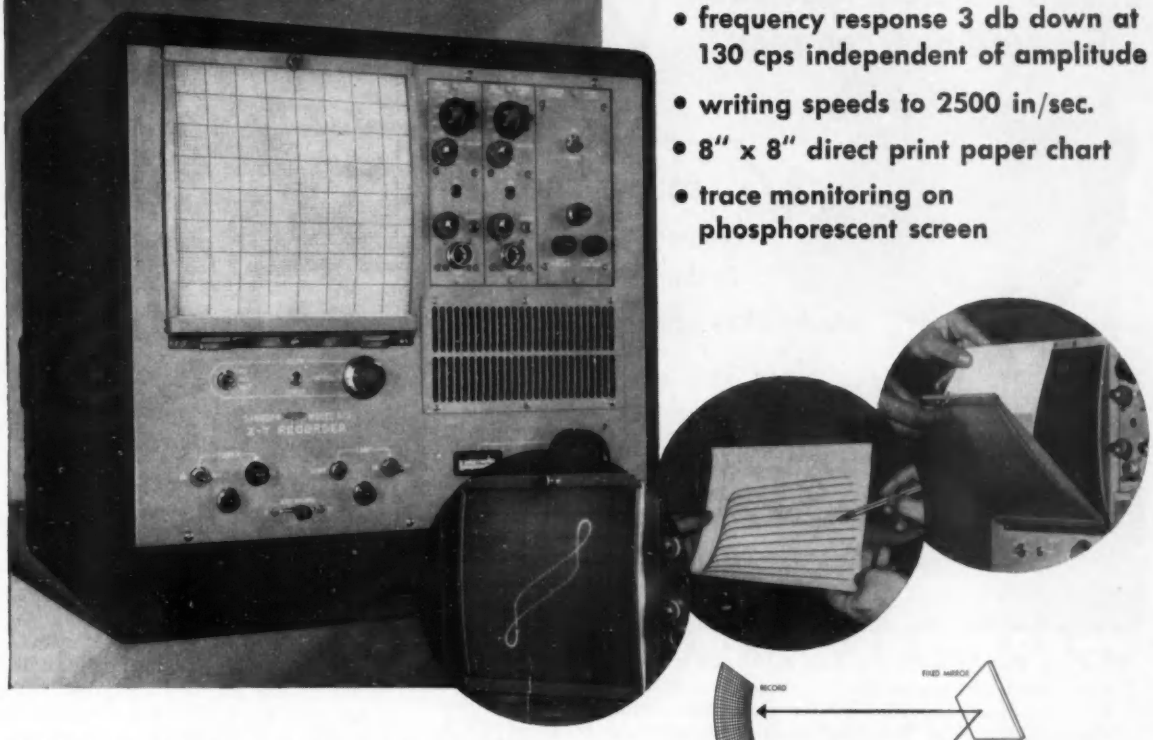
Circle No. 219 on reply card

THREE NEW ADDITIONS

Now in full production, three new MetalFilm strain gages have been designed for specific application: a rosette gage, with a 3-gage 45-deg geometry, for use on high-performance aircraft and missiles; a miniature gage, measuring $\frac{3}{32}$ by $\frac{3}{32}$ by 1/1,000 in. thick, for use in steep strain gradient

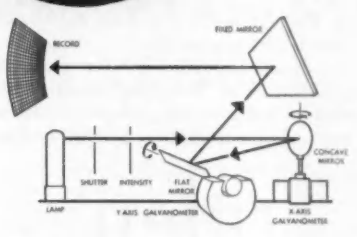
100 CPS X-Y RECORDING

with immediate readout



THE NEW SANBORN MODEL 670 OPTICAL X-Y RECORDER HAS

- 1% linearity
- frequency response 3 db down at 130 cps independent of amplitude
- writing speeds to 2500 in/sec.
- 8" x 8" direct print paper chart
- trace monitoring on phosphorescent screen



X-Y RECORDING never before possible with electro-mechanical instruments can now be done with the new Sanborn Model 670 X-Y Recorder. Direct writing on ultraviolet-sensitive recording paper by a beam deflected by optical galvanometers makes possible the combination of fast writing speed and 130 cps frequency response not found in any other X-Y recorder. Transistor characteristics, acceleration and vibration of mechanical parts and events of similar short duration can be recorded with linearity of *1% of full-scale* and at trace speeds as fast as *2500 inches per second*. Square wave response exhibits no greater than ½% overshoot *at any amplitude;* sensitivities as high as 62.5 uv/inch (depending on preamplifier used).

PLOTS OCCUPY AN 8" x 8" RECORDING AREA and can be previewed or monitored on the instrument's phosphorescent screen. An Axis Record switch to print X and Y axes on the record, and a Beam Intensity Control to assure maximum trace clarity, are among the front panel controls provided. An 8" x 8" sheet of the ultraviolet-sensitive chart paper (stored in drawer at base of cabinet) is easily placed on the back of the hinged screen. Brief post exposure in normal room light is the only developing process.

OPTIONAL INTERCHANGEABLE PREAMPLIFIERS for each axis presently include the Model 850-1300B DC Coupling and Model 850-1200 Phase Sensitive Demodulator; a Carrier Preamplifier, High Gain Preamplifier and a time base generator are now in development. Driver Amplifiers are compact, fully transistorized plug-in units with single-ended input and output. Galvanometers are low resistance, low voltage units of rugged, enclosed construction; sensitivity and damping are independent of coil temperature. Accessible, unitized circuitry also extends to the power supplies—a front-panel plug-in for both preamplifiers and a second supply for both driver amplifiers. A built-in blower provides constant, forced filtered air cooling. The Recorder can be rack mounted in 15¾" of panel space, or housed in its own 20" x 20" x 21¼" optional portable cabinet.

Ask your local Sanborn Sales-Engineering Representative for complete information on the Model 670 X-Y Recorder, or write the Industrial Division in Waltham, Mass.

SANBORN COMPANY

INDUSTRIAL DIVISION

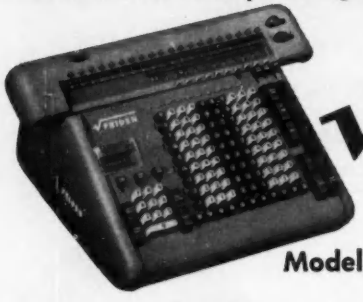
175 WYMAN STREET, WALTHAM 54, MASS.

CIRCLE 95 ON READER-SERVICE CARD

FRIDEN MODEL SRW...

"in no time"

does a problem that once was tedious, complex



√ SQUARE ROOT ...appears automatically in the dials of Friden Model SRW when you touch one key

SEE HERE HOW IT'S DONE

1 Set number from which root is to be taken on Friden SRW keyboard

2 Touch Square Root key corresponding to position of decimal point in the radicand

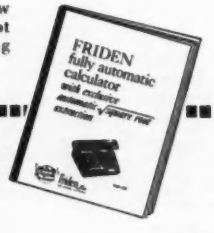
3 See root appear in dials. This figure can be retained on keyboard if desired for further calculation. Need for copying root is eliminated

For the first time on any desk calculator Friden Model SRW provides touch-one-key extraction of square root. This of course is in addition to all standard Friden Calculator features. Thus Friden Model SRW is The Thinking Machine of American Business *PLUS.* It performs more steps in figure-work *without operator decisions* than any other calculating machine. Can you use one?

Friden ...WORKS THE WORLD'S FIGURE-THINKING PROBLEMS AUTOMATICALLY

Friden sales, service and instruction available throughout the U.S. and the world ...Friden Silver Anniversary • 1934-1959

Send for new Square Root Calculations Manual. Tells how calculating machine with unique automatic square root extraction feature does higher mathematics including triangulation, statistics. Free—no obligation.



FREE

FRIDEN, Inc. Dept. CE-759
San Leandro, California

Please send Square Root Calculations Manual to:

Name_____

Company_____

Address_____

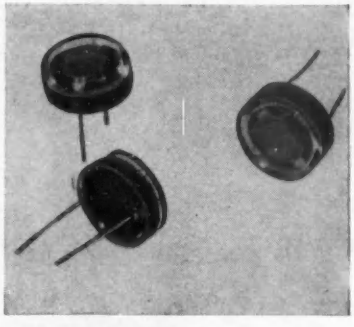
City_____ Zone____ State_____

CIRCLE 96 ON READER-SERVICE CARD

NEW PRODUCTS

areas; and a high-fatigue-life unit for measuring severe high-speed dynamic strains. Resistance values are 120 ohms for each section of the rosette gage, 60 ohms for the miniature unit, and 500 ohms for the high-fatigue-life type. Largest of the three is the rosette gage which is ¼ in. square. —Tatnall Measuring Systems Co., Phoenixville, Pa.

Circle No. 220 on reply card



LIGHT SENSITIVE

These small, light-dependent resistors consist of cadmium sulfide cells with silver electrodes. For a light intensity change from total darkness to 1,400 foot-candles, their resistance ratio exceeds 25,000 to 1. Benefits include long life, low cost, and the elimination of high-gain amplification stages.—Ferroxcube Corporation of America, Saugerties, N. Y.

Circle No. 221 on reply card

SAVES POWER & TIME

Already in service on a number of well-known missiles, a new unheated, floated rate gyro features a built-in mechanism for temperature compensation. A bellows, a slotted spring steel damping cylinder, and a fixed can surface mechanically maintain stability of the gyro over a wide temperature range. The new design completely eliminates the 50 to 100 watts of heater power required in other units to continuously maintain the highest expected temperature. It also eliminates the 10-to-30-min warm-up time. Unit operates at 150 g shock and 25 g vibration.—Ketay Dept., Norden Div., United Aidcraft Corp., Commack, N. Y.

Circle No. 222 on reply card

FOR THE ENGINEER

who can't sleep nights

If you're losing sleep over a sticky problem in automatic control, AE can help—because AE has a reputation for making things *work* automatically.

It's not surprising, considering our unique experience in the design of circuits and components for automatic telephone exchanges.

What's more, AE relays and stepping switches are unique in their own right—because they're built to have substantially zero variation in operating characteristics *for life.*

As an example: the AE Class B Relay, illustrated, provides hundreds of millions of operations with unfailing contact reliability, and seldom needs maintenance. For this reason, it is probably the most inexpensive relay you can use where infallibility is an essential.

AE relays and stepping switches are custom-made to *your* specifications—and are also available wired and assembled into complete control units. And we're always glad to suggest specialized circuits that may cut your end costs.

Want more information? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

Also yours for the asking: Circular 1702-E, *Relays for Industry,* and a new 32-page booklet on *Basic Circuits.*

AE CAN DO

AUTOMATIC ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

GENERAL TELEPHONE SYSTEM

CIRCLE 97 ON READER-SERVICE CARD

RAMBLINGS ON INSTRUMENTATION

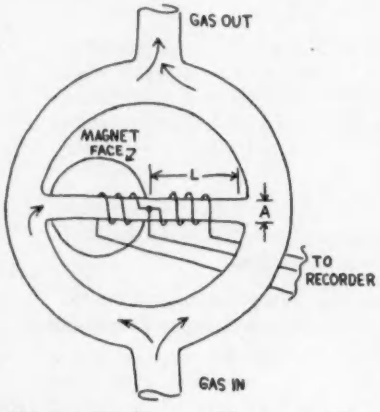
Confessions of an R&D Spy

While waiting nervously for one of the rare audiences granted by our Chief Engineer, our eyes lit on a memo stamped "TOP SECRET" lying on his desk. Feeling somewhat guilty, we scanned it. It began: "Chief, don't blab this to Sprague but . . . "

Feverishly, we read on. The gist of it was that good old R&D had succeeded in developing a new low range oxygen analyzer that meets some rather stringent specs we handed them a short while ago. Not only, we read, does the product meet the specs but it *is already in production!* (Our R&D Department takes a motherly attitude toward new products. When somebody buys one it's almost like having a son leave home. Hence the secrecy.)

Using private-eye methods, we succeeded in ferreting out further information of possible interest to customers. The specs of our new model 632 Analyzer, for instance:

Ranges: 0 to 1%, 0 to 2%, 0 to 3% O_2
Accuracy: ± 2% of Range
Zero Stability: ± 1% of Scale
Time Constant: 5 to 7 seconds
Hydrogen Insensitivity: To 50%



"Magnetic Wind" generated by presence of O_2 in sample produces flow of gas from left to right, cooling left hand and warming right-hand windings.

The analyzer works on a new concept of a principle we've proved out for over a decade in our Standard Magno-therm O_2 Analyzer. That is, that oxygen—almost alone among common gases—is paramagnetic. By somehow measuring variations in the paramagnetic properties of a given volume of gas, our analyzer develops a highly accurate reading of its oxygen content. It measures like crazy even when changes are as miniscule as .01% O_2. And there are no moving parts to be oiled, greased, sharpened, ground, re-wound or degaussed.

The important characteristic of Hydrogen insensitivity can be easily explained, according to our Engineer, by this sketch of the analyzing cell coupled with the impressive formula:

$$Q = k \triangle TA \frac{1}{L}$$

where Q is the amount of heat transferred due to the thermal conductivity of the gas. Since A, area of the cell cross member, is small with respect to its half length, L, the value of Q is negligible.

Suppressed Ranges

If your problem is getting an accurate measurement of king-sized quantities of oxygen, we can supply this analyzer calibrated for Suppressed Range O_2, operation, e.g. 98 to 100% or 18 to 21% O_2.

From the foregoing, any man with an oxygen measurement problem can easily deduce that the Hays Low Range and Suppressed Range O_2 Analyzers have features that beggar description. Our Chief Engineer has tentatively agreed to release the complete details to those prospective customers with proper credentials.

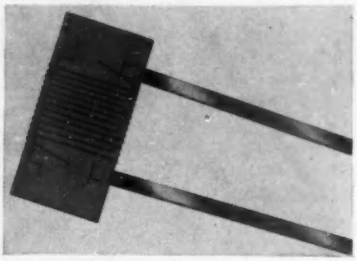
However, I suggest you write directly to me, with or without credentials. Having an intense fiscal involvement in the matter, I personally guarantee to send you either the information or the Chief Engineer himself, whichever appears more lucid.

Phil Sprague Jr.
President

THE HAYS CORPORATION • MICHIGAN CITY 37, INDIANA

CIRCLE 98 ON READER-SERVICE CARD

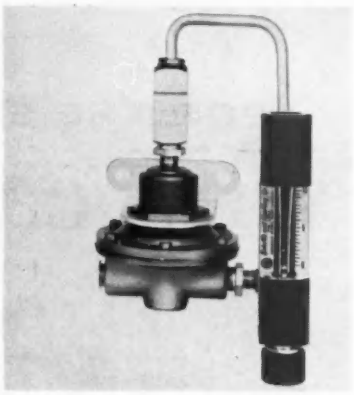
NEW PRODUCTS



¼-SEC RESPONSE TIME

Shown is one of three new high-temperature resistance thermometers which, when properly bonded to flat surfaces, have time constants as short as ¼ sec. Units feature Hytemco grids and nickel lead wires, and will operate continuously at 800 deg F. Self-heating error is only 1 percent with a 15 ma current.—Arthur C. Ruge Associates, Inc., Hudson, N. H.

Circle No. 223 on reply card



FOR SMALL FLUID FLOWS

In the photo above, a differential regulator has been combined with one of the new SK Purge Rotameters to provide simple automatic control for all types of normal purging applications. By itself, the Purge Rotameter represents an inexpensive, quality instrument for indicating small flows such as the flow of supply air, purge fluid, or sample fluid in various industrial control systems. Available in five different meter tube sizes, these units cover flow ranges of from 0.6 to 4.5 gph water, or 0.5 to 35 cfh air. They provide good reproducibility and moderate measuring accuracy. —Schutte and Koerting Co., Cornwells Heights, Pa.

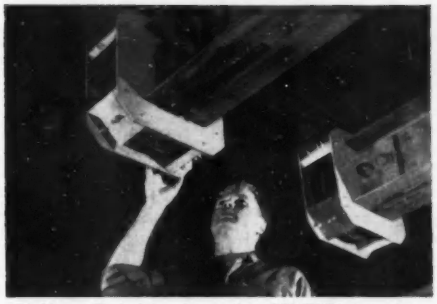
Circle No. 224 on reply card

JOURNAL OF APPLIED CONTROL DEVICES THAT NEVER WEAR OUT

For Control Engineers Who Are Wearing Out Before Their Time

ALCOA DISCOVERS WONDERFUL NEW WORLD OF INDUSTRIAL TELEMETERING

Aluminum Company of America engineers have just cut the cost of measuring large amounts of direct current used in smelting operations by replacing conventional meter-and-shunt arrangements with CONTROL'S transductors. Beyond cost-cutting, the installation at Alcoa's new plant at Massena, New York, sets new highs in operating reliability, convenience and safety. Telemetering of a hot 8,000 amperes at 600 volts is done over a distance of several hundred feet, with no direct connection to the bus bars which carry the heavy current! The CONTROL transductor is in essence a d-c current transformer, and unlike the meter-with-shunt, it can be used for remote measurements, regardless of distance—and still retain its guaranteed ± 1% accuracy. *This is static control, and it's based on high permeability magnetics. A transductor catalog awaits your request.*



At Alcoa: Technician inspecting CONTROL transductor, one of 48 measuring 8,000 amperes at 600 volts.

STATIC CONTROL= TRANSDUCTOR = SIMPLICITY

What appeals to engineers (Alcoa and otherwise) about CONTROL transductors is their simplicity. Two Orthonol® (nickel-iron alloy) cores are connected electrically in opposition, the bus bar runs through them, and you have the world's simplest device for measuring large currents over long distances. No need for calibrated leads (as with meter-and-shunt). They are comparatively easy to cut into the line—mount like donut current transformers. The transductor loops around the bus and is not even directly connected to it! Alcoa sums the readings from several transductors measuring different bus lines simply by feeding their outputs into a totalizing transformer. Potential differences of the lines being summed have no effect. *Our catalog shows the simple circuitry, and details the full range of transductor sizes from 200 to 25,000 amperes. Write for your catalog.*

At Alcoa—Several hundred feet away: Readings are taken on both individual transductor meters and totalizing meter.

ALL THIS . . . AND THE RIGHT PRICE, TOO!

We're selling a lot of transductors. It's their flexibility that catches the customers. *To wit:* Variations in ambient temperature, or stresses on the bus bar as the building settles have no effect on accuracy. *To wit:* They provide a usable power output: you can run relays and magnetic amplifiers directly from the transductor with no booster amplifier. *To wit:* Additional accessory meters can be easily added at a later time. *To wit:* They install easily. You open the line, slip on the CONTROL transductor, reconnect—and the job is done. *And—they are competitively priced! The higher the ratings, the less they cost compared to competitive methods. Prices and complete information await your immediate request.*

Reliability begins with CONTROL

A DIVISION OF MAGNETICS, INC.

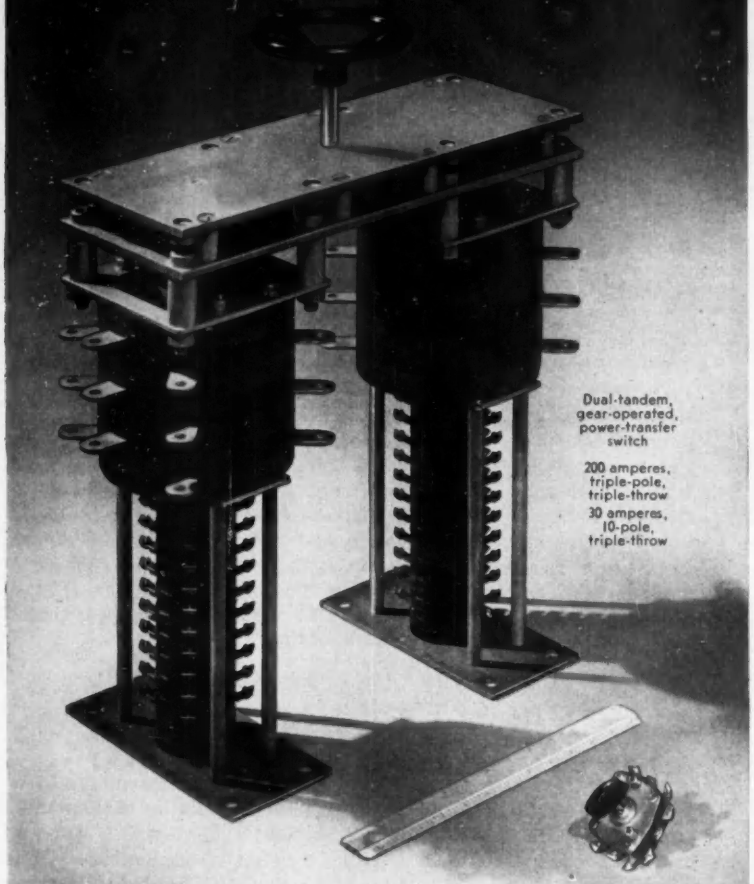
DEPT. CE-68, BUTLER, PENNSYLVANIA

CIRCLE 99 ON READER-SERVICE CARD

WE MEAN IT...

... when we say

"ESCO will make special rotary switches to meet your requirements".



Unusual
or highly specialized
circuit control requirements
can be met by special combinations
of standard ESCO components. This includes
switches to comply with BuShips drawings
and MIL specifications.

Write for Bulletin No. 8

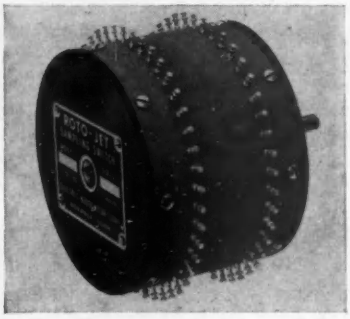
ESCO of WEYMOUTH

ELECTRO SWITCH CORPORATION

167 King Avenue, Weymouth 88, Massachusetts

CIRCLE 100 ON READER-SERVICE CARD

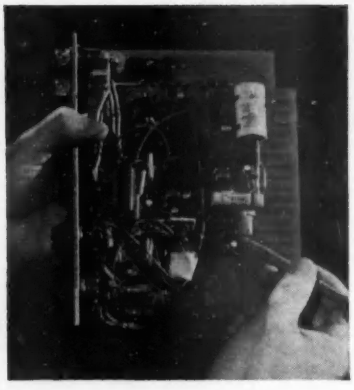
CONTROLLERS, SWITCHES & RELAYS



AIR-OPERATED SAMPLER

The Roto-Jet noiseless, sequential sampling switch houses up to 45 peripheral contact pairs which are actuated sequentially by a rotating jet of air. Operating speed exceeds 3,600 closures per sec. Two-pole switching, at any phase angle, can be supplied by adding a second row of contact pairs and a second air jet synchronized at the desired angle.—Electric Regulator Corp., Norwalk, Conn.

Circle No. 225 on reply card



STATIC PROTECTIVE RELAY

Offered as the first major departure from the mechanical induction disc design introduced almost 50 years ago, the A-C Static Protective Relay is ½ the size of its predecessors, and contains no moving parts. All components are mounted on a printed circuit board secured to a metal frame. An epoxy potting compound makes the entire

DELCO POWER TRANSISTORS

NEW TYPES

MILITARY
COMMERCIAL

TYPICAL CHARACTERISTICS AT 25°C

EIA	2N297A*	2N297A	2N665**	2N553
Collector Diode Voltage (Max.)	60	60	80	80 volts
HFE (I_c = 0.5A) (Range)	40-100	40-100	40-80	40-80
HFE (I_c = 2A) (Min.)	20	20	20	20
I_{co} (2 volts, 25°C) (Max.)	200	200	50	50 μa
I_{co} (30 volts, 71°C) (Max.)	6	6	2	2 ma
F_{ae} (Min.)	5	5	20	20 kc
T (Max.)	95	95	95	95°C
Therm Res. (Max.)	2	2	2	2° C/W

*Mil. T 19500/36 (Sig. C.)
**Mil. T 19500/58 (Sig. C.)

NOTE: Military Types pass comprehensive electrical tests with a combined acceptance level of 1%.

Delco Radio announces new PNP germanium transistors in 2N553 series — the 2N297A and 2N665, designed to meet military specifications. These transistors are ideal as voltage and current regulators because of their extremely low leakage current characteristics. All are highly efficient in switching circuits and in servo amplifier applications, and all are in *volume* production! Write today for complete engineering data.

DELCO RADIO
Division of General Motors • Kokomo, Indiana

BRANCH OFFICES

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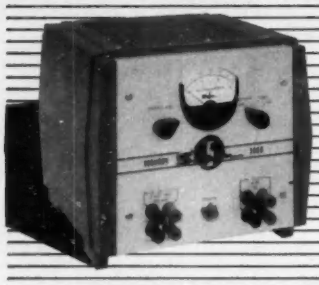
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

CIRCLE 101 ON READER-SERVICE CARD

NEW IDEAS IN PACKAGED POWER

for lab, production test, test maintenance, or as a component or subsystem in your own products



New addition to Sorensen B-supply family features outstanding versatility. A voltage range of 0-300 vdc, at up to 150 ma, regulation within ±0.15% or 0.3 volt, complete flexibility as to polarity or grounding, heater supplies of either 6.3 or 12.6 volts ac, and provisions for external sensing are big features of the new Sorensen Model 300B (left). It's one of the most adaptable B supplies ever. Outputs of two Model 300B's may be connected in parallel for higher current or series for higher voltage without introducing instability or impairing regulation. Model 300B may also be connected to supply constant current within a specified range. Sorensen has B Nobatrons to supply almost every need of electronic research lab or precision equipment builder. They come in output voltages up to 1000-vdc; models have adjustable front-panel controls and hold their regulation over an astonishingly wide voltage range. Bench or rack-mounting models. Write for specs.

New unregulated supplies offer economy, wide adjustment range. Unregulated, but highly adjustable, the new Sorensen RC-Nobatron Rangers, like the Model RC36-30 (left), are exceptionally simple and rugged d-c supplies consisting basically of a variable autotransformer and rectifier-filter circuit. They come in models to supply 0-36 or 0-150 vdc and each model has an auxiliary a-c output of 0-130 vac. Each voltage range comes in two power capacities (approximate maxima): (1) 500 watts dc and (2) 1 kw dc. A transformer completely isolates d-c output from a-c input and output; entire circuit is completely isolated from chassis ground. D-c output voltmeter and ammeter supplied. Available for bench or 19" rack. All models: 115 vac, 60 cps. 8.45

See your nearest Sorensen Representative or write us for complete details on these new Sorensen d-c power supplies. And may we remind you that our engineers are always ready to consider your special power supply needs, whether this involves modification of an existing unit or the design of a complete power system to meet complex requirements.

Sorensen

SORENSEN & COMPANY, INC.

Richards Avenue, South Norwalk, Connecticut

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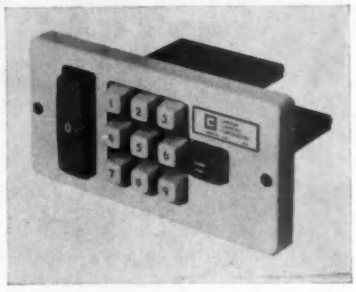
CIRCLE 102 ON READER-SERVICE CARD

NEW PRODUCTS

unit insensitive to shock and moisture. Response of its solid-state components enables the relay to delay tripping if a given overcurrent condition improves, and advance tripping if the condition becomes more severe. Front panel control knobs permit time and range settings; neon lights provide instantaneous and time trip indications. —Allis-Chalmers Mfg. Co., Milwaukee, Wisc.

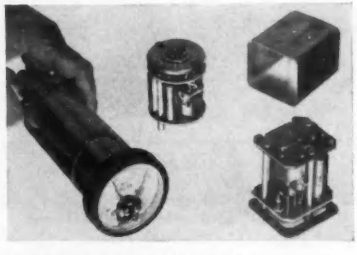
Circle No. 226 on reply card



CLEAN DESIGN

The Model 3030 Numerical Push Button Station, designed for manual data input operations, combines simple rugged construction with clean functional design. Momentary contact buttons have been spaced on $\frac{7}{8}$ in. centers to reduce the possibility of accidental operations of more than one button at a time. Manufacturer will furnish the unit with any combination of two form A, B, or C contacts per station. Contacts are rated at 3 amp, 110v, non-inductive. Panel opening required is $6\frac{1}{2}$ in. by 3 in. high.—Carlton Controls Corp., Worcester, Mass.

Circle No. 227 on reply card



PACKAGED CONTROLS

Photo illustrates some of the new miniaturized control circuits that have been built around the API meter-relays. Both round and rectangular

KLIXON®

CIRCUIT BREAKERS, PRECISION THERMOSTATS, SWITCHES and OVERHEAT PROTECTORS

For Electronic, Radar and Radio Equipment, Ground Support Equipment, Missiles and Aircraft Controls

KLIXON KX-5 SERIES PRECISION SWITCHES

Hermetically sealed snap-acting limit switches. Seal uses metalized ceramic terminal inserts and metal diaphragm. Switching element, one-piece sine blade. Steel case withstands high impact and compression loads. High temperature resistance to 375°F. Vibration resistance to 25 g's, 0-2500 cps. Ratings to 10 amperes, 115 VAC or 30 VDC resistive. 25,000 cycles minimum life. Ambient temperatures range, −65°F to +375°F. Weight 1 oz. Variety of actuators available.

NEW KLIXON M1 PRECISION THERMOSTAT

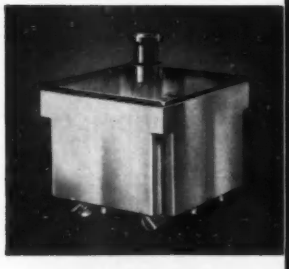
Hermetically sealed, vibration resistant, snap action. Gold plated contacts for dry circuit applications. Conforms with MIL-E-5272A and MIL-T-5574A. Preset and non-adjustable. Temperature settings from −65°F to +400°F. High dielectric strength 1250 VAC. Ratings up to 7 amperes, 30 VAC/DC resistive; or 6 amperes, 125 VAC; or 3 amperes, 250 VAC. Weight 5 grams. Special high-reliability version with low differential (9°F) available.

NEW KLIXON 2862 PRECISION THERMOSTAT

Positive temperature control for three-phase systems. Hermetically sealed, fixed temperature, snap action. Controls three phases simultaneously. Temperature settings from −65°F to +325°F. Minimum differential: 25°F. Rating 5 amperes, 120 VAC, 60/400 cycles. Variety of mounting brackets available.

NEW KLIXON 7274 MICRO-MINIATURE CIRCUIT BREAKER

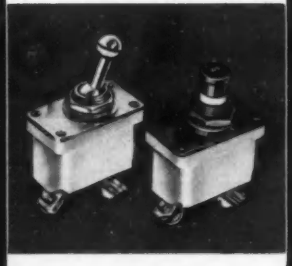
Simple push-pull, trip-free design. Available as shown SPST with 6/32 screw-type terminal or mounting to replace NAF-1357 front-mounted fuse. Also SPDT with N/O auxiliary contacts and 4 solder terminals. Exceptionally small — height 1.420", width 0.744", depth 0.562". Ratings ½ to 5 amperes. Ultimate trip @ 77°F, 115-145%. 200% trip, 2-15 seconds. Vibration resistance 10 g's, 10-500 cps. Shock resistance 25 g's. Weight only 0.9 oz.



NEW KLIXON D6760 SIMULTRIP* CIRCUIT BREAKER

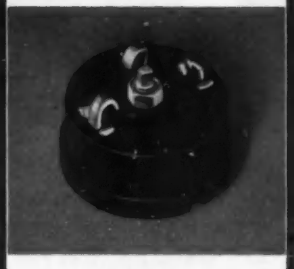
Thermal type, three phase. Interrupts high AC short circuits . . . trips quickly . . . provides simultaneous tripping of all three phases should any one phase become overloaded. Phases can be different ratings. Ratings 5 to 60 amperes. 120/208 VAC, 60/400 cycle systems and 220/440 VAC, 60/400 cycle systems. Weight 227 grams. Minimum AC rupture capacity 2500 amperes, 1 ϕ, 120 VAC, 400 cps. Ultimate trip @ 77°F, 105-130%. 200% trip, 10-65 seconds.

*Trade Mark



KLIXON D7270-D7271 CIRCUIT BREAKERS

Two miniature breakers different only in actuators. Simple trip-free design about ½ the size of MS25005 and MS25017. Only three moving parts — actuator, slide and thermal disc. Ratings 3 to 35 amperes; weight 1.5 ozs. High rupture capacity 3500 amperes, 120 VAC, 400 cps; 4,000 amperes, 30 VDC.



KLIXON SINGLE-PHASE INHERENT OVERHEAT PROTECTORS

Protect transformers, solenoids, electric motors against excessive temperatures. Responsive to both temperature and current. These types are for single-phase inductive equipment with maximum continuous operating temperatures up to 225°C. Maximum rupture capacity is 750 amperes, 200 VAC, 400 cycle. Available in automatic and non-automatic reset types.

NEW KLIXON THREE-PHASE INHERENT OVERHEAT PROTECTORS

Designed to match the thermal and electrical characteristics of inductive equipment, they prevent protected components from reaching destructive temperatures without limiting useful output. For 3-phase equipment with maximum continuous operating temperatures up to 225°C. Maximum rupture capacity is 400 amperes, 200 V, 400 cycles. Available in open and hermetically-sealed construction in automatic and non-automatic reset types.

KLIXON Circuit Breakers, Precision Switches, Precision Thermostats and Overheat Protectors are small in size and light in weight; they respond quickly and with accurate repeat performance; they have ample capacity to handle a wide range of electrical loads; their calibrations stand up in the face of severe environmental conditions.

Competent Metals & Controls engineers at the factory and in the field will gladly make test applications of the KLIXON Line. Write for "KLIXON Controls for Electronic Equipment, Aircraft and Guided Missiles" Catalog.

METALS & CONTROLS

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SPENCER PRODUCTS: Klixon® Inherent Overheat Motor Protectors • Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

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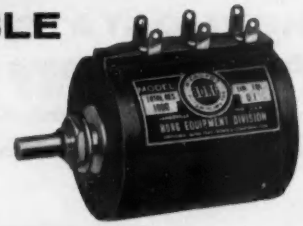
BORG 1100 MICROPOTS...

HIGH RELIABILITY AT A SENSIBLE PRICE...



...heavy-duty scales... another Borg Micropot application

Seldom, if ever, will you find another potentiometer offering the advantages found in the Borg 1100's price range. Total resistance 25 to 100,000 ohms. Independent linearity accuracy 0.5% to 0.1%. Life of better than 500,000 revolutions. Borg 1100 Micropots are available with lug-type terminals or coded flexible leads. The price? You'll be amazed! Contact Borg today.

Ask for catalog BED-A90

BORG EQUIPMENT DIVISION
AMPHENOL-BORG ELECTRONICS CORPORATION
JANESVILLE, WISCONSIN

MICROPOTS • MICRODIALS • INSTRUMENT MOTORS • FREQUENCY STANDARDS
CIRCLE 104 ON READER-SERVICE CARD

models are available. Round models use a 2½-in. indicating meter-relay; self-contained power supplies and other circuit components are housed in 2-in. diam barrels that range in length from 2 to 5 in. Rectangular models, measuring approximately 2 by 2¼ by 2¾ in., use built-in VHS non-indicating meter-relays. Both types can be used to trigger appropriate control action at adjustable set points.—Assembly Products, Inc., Chesterland, O.

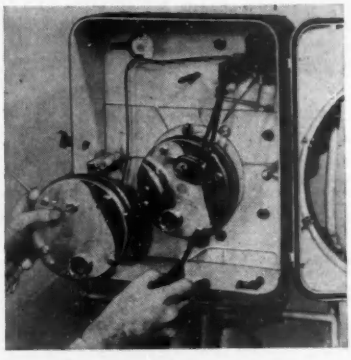
Circle No. 228 on reply card

PACKAGED LOGIC

Logic units in the square D Static Control line duplicate the functions of machine tool relays, stepping relays, latching relays, and timers; and at the same time provide space economy, unlimited life, improved reliability, and instantaneous response. Called NOR-PAKS, these units consist of multiple transistor NOR circuits which can be arranged to perform any of the common logic functions (AND, OR, NOT, and MEMORY).—Square D Co., Milwaukee, Wis.

Circle No. 229 on reply card

POWER SUPPLIES



GAS DRIVE FOR CHARTS

Designed to operate without attention as long as gas pressure is available, the Rockwell Gas Drive provides power for the accurate and automatic operation of recording charts. The unit is particularly suited for remote installations such as off-shore oil wells and

One of these handy prepaid post cards will bring you detailed information

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2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192
3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193
4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194
5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195
6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196
7	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197
8	18	28	38	48	58	68	78	88	98	108	118	128	138	148	158	168	178	188	198
9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199
200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390
201	211	221	231	241	251	261	271	281	291	301	311	321	331	341	351	361	371	381	391
202	212	222	232	242	252	262	272	282	292	302	312	322	332	342	352	362	372	382	392
203	213	223	233	243	253	263	273	283	293	303	313	323	333	343	353	363	373	383	393
204	214	224	234	244	254	264	274	284	294	304	314	324	334	344	354	364	374	384	394
205	215	225	235	245	255	265	275	285	295	305	315	325	335	345	355	365	375	385	395
206	216	226	236	246	256	266	276	286	296	306	316	326	336	346	356	366	376	386	396
207	217	227	237	247	257	267	277	287	297	307	317	327	337	347	357	367	377	387	397
208	218	228	238	248	258	268	278	288	298	308	318	328	338	348	358	368	378	388	398
209	219	229	239	249	259	269	279	289	299	309	319	329	339	349	359	369	379	389	399

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Use these reader service cards to get more information on advertised products, new product items or catalogs and bulletins appearing in Control Engineering

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The sum total of the skills involved in the conception, design, development and manufacture of complete optical systems frequently cuts across many fields. Kollmorgen combines technical skill and complete facilities for highly precise work in optics, mechanics and electronics. From the engineering design and mock-up stages through development, manufacture and final testing, Kollmorgen can handle the *whole* job.

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Continuous strip fuel inspection cameras. Hot cell periscopes, underwater periscopes.

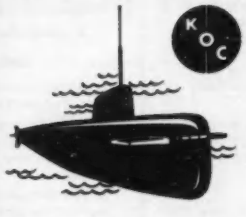
Periscopes can be provided with Radiation Resistant Optics, Internal Radiation Shielding, Corrosion Resistant Materials, Pressurized Construction, Interchangeable Viewing Heads, Interchangeable Eyepieces, Microscope Relays and Camera Attachments.

MISSILE PERISCOPES

These bunker-type periscopes are designed by Kollmorgen to customer specifications. They allow close, detailed observation during launching, static tests and fueling operations without endangering the viewer. As in all Kollmorgen periscopes, the excellent light-gathering power of these instruments makes them easily adaptable for photography or television purposes. All are hermetically sealed and maintenance-free.

PRECISION OPTICS

Kollmorgen's well-equipped optical shops produce all types, shapes and sizes of lenses, prisms and mirrors to meet the most exacting requirements of industry and defense. Quantities from one of a kind to production runs of thousands. Individual elements or complete optical systems.



SUBMARINE PERISCOPES

The Nautilus and her sister ships of the atomic fleet, like almost all other U. S. submarines, are equipped with periscopes designed and manufactured by Kollmorgen.

SPECIAL PRODUCTS

Borescopes—in lengths from a few inches to forty feet, diameters from .100" to two inches. Motion picture and television lenses. Riflescopes for the military. Optical training devices. Collimators. Transit optics. Electronic devices (classified). Aerial camera and bombsight lenses.

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optical corporation
NORTHAMPTON, MASSACHUSETTS

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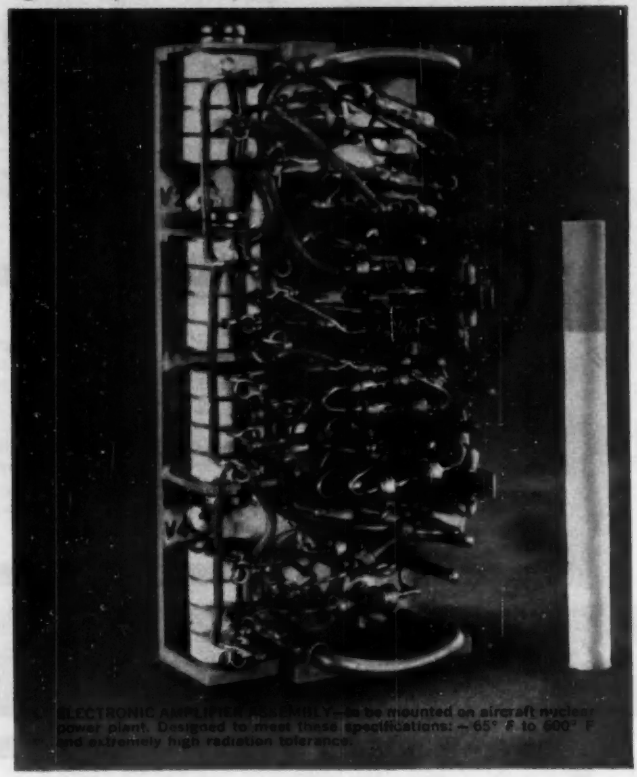
Engineers from many fields EE, ME, Metallurgy, Physics



ELECTRONIC AMPLIFIER ASSEMBLY—to be mounted on aircraft nuclear power plant. Designed to meet these specifications: —65° F to 600° F and extremely high radiation tolerance.

Exploring New Areas in Controls and Instrumentation for Nuclear Powered Flight

The peculiar characteristics of a reactor as a power source for flight require a new approach to controls system engineering at General Electric's Aircraft Nuclear Propulsion Dept.

Many problems are introduced – not associated with chemically powered engines, for instance:

RADIATION and HIGH TEMPERATURE CONSTRAINTS. For example, electronic sub-systems – such as the Electronic Amplifier Assembly pictured above can operate reliably under high gamma and neutron bombardment and at 600° F. This calls for new materials and new processing techniques – and consequently, new design concepts.

MINIMUM SIZE and MINIMUM WEIGHT commensurate with optimum performance—a requirement of the entire aircraft nuclear propulsion program.

The bulk of the reactor control systems mechanisms and circuitry is developed at the ANP Control System Laboratories. The development of Controls and Instrumentation for a power reactor for aircraft naturally involves direct testing in reactors. Much developmental work is also conducted with analog simulators.

CURRENT OPENINGS FOR:

Electrical Engineers
Physicists
Metallurgists
Mechanical Engineers
Engineering Physicists

AREAS:

1. Development of Nuclear and Temperature Sensors
2. Development of high temperature, radiation resistant electrical and electronic circuitry
3. Systems Analysis and Design of nuclear power plant control systems.

Write in strict confidence, stating salary requirements, to:
Mr. P. W. Christos, Div. 22-MG
AIRCRAFT NUCLEAR PROPULSION DEPT.

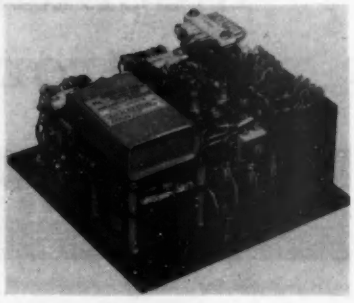
GENERAL ELECTRIC

P.O. Box 132, Cincinnati 15, Ohio

NEW PRODUCTS

gas gathering systems where manual winding or electrical operation becomes difficult. Features include a self-starting mechanism, explosion-proof construction, and an internally-sealed timing mechanism. A 25-psi air or gas supply enables the unit to deliver a 12-lb-in. output torque at an arbor speed of one revolution in 24 hr. Gas consumption is only 4 cu ft per day.—Rockwell Manufacturing Co, Pittsburgh, Pa.

Circle No. 230 on reply card



POWER INVERTER

Developed for use in missiles missile checkout systems, and aircraft equipment, this solid-state static power inverter converts a 26-30 vdc input to a 115-volt, 400-cycle ac source with a stable 250-va power output. Makers claim a life expectancy for the unit of 20,000 hours under continuous operation. It will withstand vibrations to 2,000 cps and shocks as high as 30 times its weight. Output voltage is adjustable to plus or minus 5 percent —Magnetic Amplifiers, Inc., New York, N. Y.

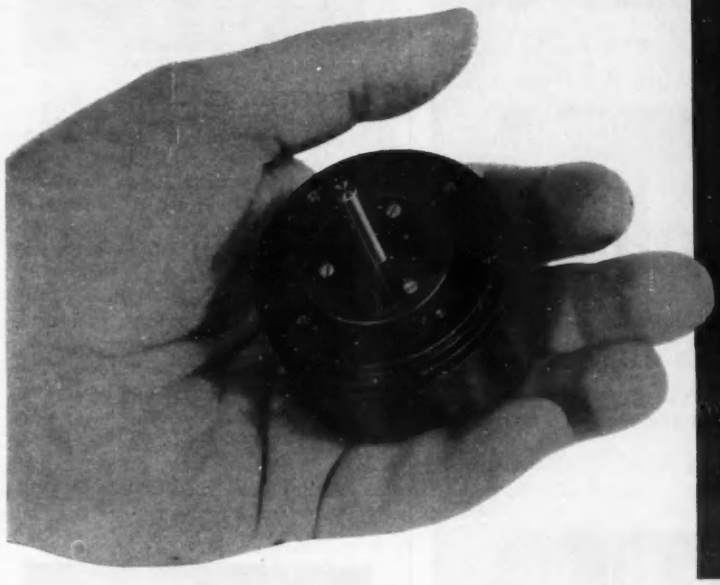
Circle No. 231 on reply card

SETS ENDURANCE RECORD

The first hydraulic pump to complete a grueling 1000-hr qualification test, using a new fire-proof hydraulic fluid, has just been placed in production. Four of these units will provide the hydraulic power for flight controls on the Convair 880 jet transport. A positive-displacement type, the pump ran through a continuous series of 2½-hr flights (400 in all) and was subjected to temperatures ranging from minus 65 to plus 225 deg F. Severe conditions simulated during the tests included: operation at discharge pressures of 4,500 psi (1,500 psi above the normal operating limit); air entrain-

ASCOP

ALL-MAGNETIC SHAFT-POSITION DIGITAL ENCODER



Operates Perfectly Under Boiling Water For One Week

Just to make it hard for ourselves, we boiled one of our shaft encoders for a week with its cover off. It worked fine both during and after the test. We weren't surprised. ASCOP shaft encoders use no active circuitry, no optical or mechanical contacts in readout. The only contacting parts are the stainless steel bearings. The ASCOP encoder is made for tough environments in all combinations. If you like, you can drag it through the water, shoot it to any altitude, pressure cook it, or bury it in the Antarctic and expect it to behave perfectly. We've effectively done all these things in our own environmental laboratory and we haven't yet extended an EPD-8G encoder to its limit. Try it yourself. We can make immediate delivery from stock.

Condensed Specifications

Resolution:	2^8
Operating Temperature Range:	−80°C to +100°C
Size:	2¼" dia. x 1¼"
Weight:	8 oz.
Code:	Gray
Inertia:	70 gm-cm²
Shock:	100G for 6 ms, 4 directions for a total of 12
Vibration:	55 cps to 2000 cps for 40 min. at 15G, and 10 cps to 55 cps for 20 min. at 0.12" amplitude

Brochure, price and applications notes on request . . .

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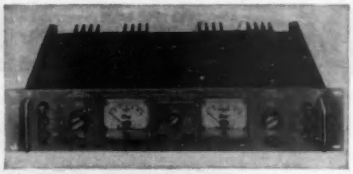
CIRCLE 107 ON READER-SERVICE CARD

NEW PRODUCTS

ment in the fluid; clogged inlet lines, and complete failure of the pressurizing equipment needed for high altitude operation.—Hamilton Standard, Div. of United Aircraft Corp., Windsor Locks, Conn.

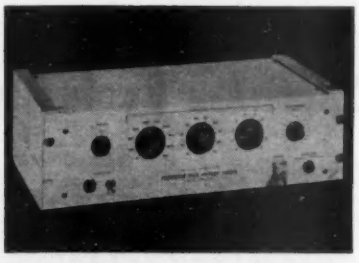
Circle No. 232 on reply card



FLEXIBLE DESIGN

This rack-mounting Model 802A supply houses two identical, but completely independent, 0-32v transistor-regulated units. If desired, these may be series operated as a single 0-64v unit with no loss of stability or regulation. Output voltage varies no more than 3 mv for a 100-percent load change or a 20-volt change (105-125v) in the line. Excellent transient response, low ripple, and built-in overload protection make the unit ideal for most transistor applications.—Harrison Laboratories, Inc., Berkeley Heights, N. J.

Circle No. 233 on reply card

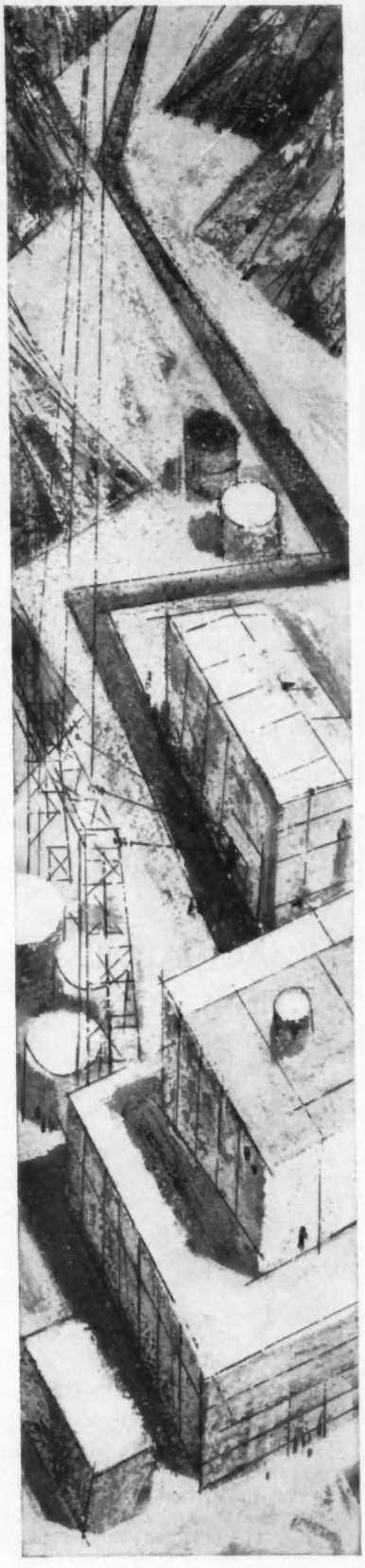


DECADE-SWITCH SELECTION

Three decade switches on the panel of this Model 240 regulated high-voltage supply permit fast accurate selection of dc voltages between 0 and 1,000. Applications include: insulation tests; diode and capacitance leakage resistance tests; meter calibration; amplifier gain checks; and excitation of ion chambers and photocells.

Characteristics

Accuracy: within 1 percent, above 10v.
Ripple: under 3 mv, rms
Protection: relay cutoff at 12 ma



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Rapidly expanding reactor development programs have provided additional challenging assignments at Atomics International. AI's modern headquarters and plant facilities, located in the San Fernando Valley of Southern California, have become a world-wide center of nuclear reactor development. Here, qualified scientists and engineers have a sound future and unlimited opportunities to advance. Currently, openings exist in:

Reactor Engineering. Analysis and design of complete power reactor systems and components. Experience in power reactor systems and technology is preferred, including a knowledge of reactor safeguard methods.

Core Analysis. Complete nuclear analysis, including criticality determinations and flux distributions. Must also be conversant with fuel economics and fuel cycle optimization.

Shielding. Design and analysis of biological and thermal shielding for large power plants and compact mobile systems.

Heat Transfer and Fluid Flow. Steady state and transient experimentation and analysis. Power optimization studies; free and forced convection flow transients; boiling and two phase flow in water, organic and liquid metal systems.

Structures. Advanced analytical studies in thermal stress analysis, structural dynamics, elastic and inelastic behavior of plates and shells. Structural analyses are performed for transient and steady state operating conditions involving mechanical loads, thermal cycling and thermal shock.

Control. Includes analysis of complete plant control and the application of electronic analogue and digital computers to reactor systems. Experience in radiation monitoring and plant protection systems is necessary.

For specific details write: Mr. G. G. Newton, Personnel Office, Atomics International, 21600 Vanowen Street, Canoga Park, California.

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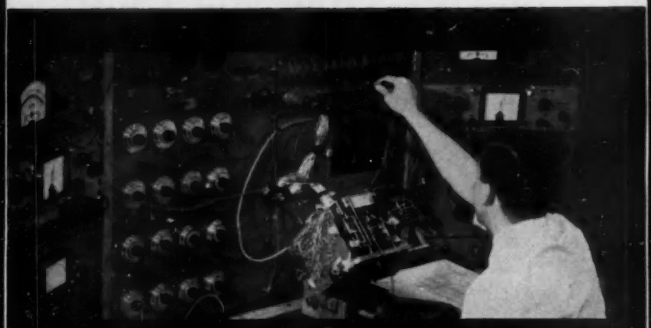

Checking resolver chains in E-P Dead Reckoning Computer System.

From twenty years' experience in designing and manufacturing resolvers, *we have developed the means of predicting exactly how resolvers of various mechanical and electrical characteristics will perform in your system under any given operational conditions.*

Nothing could be surer. You tell us the system performance you need. We analyze the requirements and supply the resolvers which will help bring you that performance. If none of our many standard resolver models fills the bill, we'll build "specials" that will.

Because we make, as standard items, just about every type of resolver and other synchros, we can usually deliver quickly and at volume production prices. Available are frame sizes 8, 10, 11 and 15. We also make cascaded resolver chains, using resolvers as small as frame size 10 with accuracy of 1/6° without using booster amplifiers.

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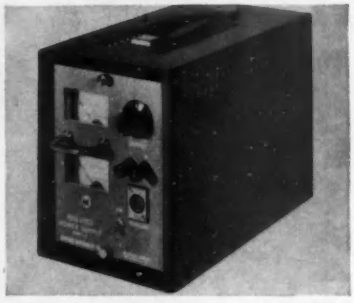
CIRCLE 108 ON READER-SERVICE CARD

NEW PRODUCTS

Load regulation: within 0.02 percent —Keithley Instruments, Inc., Cleveland, O.

Circle No. 234 on reply card

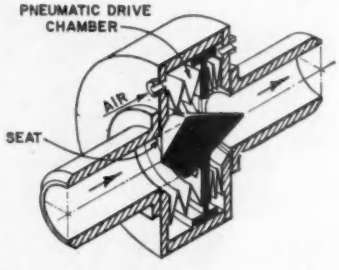


PRECISE RESULTS

Use of a specially shielded transformer and unique feedback isolation circuits completely isolates the output of this Model 21 power supply from both line voltage and line ground. The unit provides 0 to 20 volts at 1 amp regulated dc power by means of transistorized circuitry. Designed for use with bridge-type transducers, it features a special output receptacle for remote shielding of power cables—Moeller Instrument Co., Richmond Hill, N. Y.

Circle No. 235 on reply card

ACTUATORS & FINAL CONTROL ELEMENTS

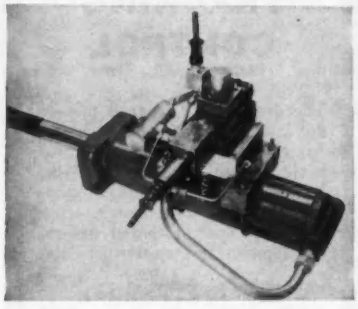


JUST CAN'T LEAK

Well suited for the handling of radioactive and toxic fluids, this compact, leakproof valve features a completely sealed fluid chamber. Only moving part is a streamlined, ring-supported plug. The outer ring of this element

slides in a pneumatic drive chamber. Bellows on either side of the ring completely isolate the fluid chamber from the air chamber. In larger models, over 2 in., mechanical gear drives replace the pneumatic drive. At present, the valve is available only to manufacturers for licensing agreements.–Singmaster & Breyer, New York, N. Y.

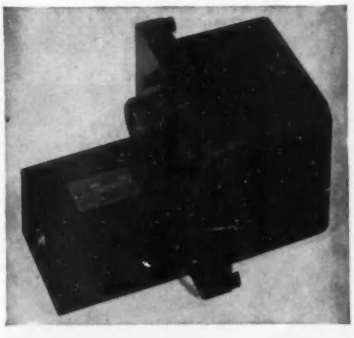
Circle No. 236 on reply card



HIGH-SPEED POSITIONING

Suitable for heavy-duty applications in the aircraft, rocket, and nuclear fields, a new series of high-speed, high-accuracy positioning systems is now available with ratings from 1 to 500 hp. Capable of speeds of 8 ft per sec on a 4-in. core cylinder, and accuracies within 0.05 percent, these units are equipped with rugged electrohydraulic actuators having operating pressures as high as 3,000 psi. System frequency response is flat to 19 cps in larger capacity systems, and up to 50 cps in smaller systems.–CompuDyne Corp., Hatboro, Pa.

Circle No. 237 on reply card



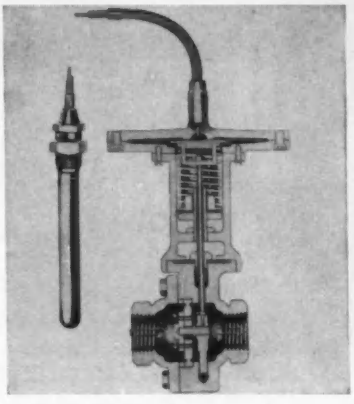
DESIGNED FOR INDUSTRY

The model SS102 electrohydraulic servovalve combines rugged construction with design simplicity. Developed specifically for industrial application this single-stage unit uses a powerful torque motor to position a 3- or 4-way spool. Torque-motor coils can be furnished to meet various specs and an lvdt may be added to provide maximum system response.

Characteristics

Supply pressure: 1,500 psi
Flow: 6 gpm at 500 psi drop
Power output: 4 hp
Power input: 5 watts
Internal leakage: 0.2 gpm
Hysteresis: 2.5 percent
–Hydraulic Controls Co., Inc., Newton, Mass.

Circle No. 238 on reply card



SERVICED WITH EASE

New design of the OPW-Jordan self-operated #180 temperature control valve features a removable thermal system that permits range changing in the field without disturbing valve stroke adjustment. A self-cleaning, sliding gate assures tight shutoff and linear flow. Stock sizes range from ¼ to 2 in. Thermal systems cover ten temperature ranges between 35 and 450 deg F.–OPW-Jordan, Cincinnati, O.

Circle No. 239 on reply card

BOOSTS RELIABILITY

A new 6-way, four-position, solenoid-operated selector valve, developed for use in aircraft hydraulic systems, combines the functions of two separate valves. Its compact design eliminates the need for two solenoids and two hydraulic-line connections previously required, improving reliability and reducing weight.–Hydra-Power Corp., New Rochelle, N. Y.

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PLUS . . .

(241)The Series "A" diaphragm valve, by **Versa Products Co.**, Brooklyn, N. Y., has been designed specifically

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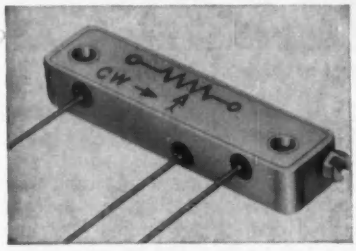
to meet the demand for a directional control valve that will operate on very low pilot or signal pressures. . . . (242) **Humphrey, Inc.,** San Diego, Calif., has added an accurately calibrated, vernier, 10-turn dial to its Servotran **Variable Speed Drives.** . . . (243) **Pressure-reducing valves** that use internal pressures for control purposes and are equally well-suited for compressible and incompressible fluids, have just been announced by the **C. E. Squires Co.,** Cleveland, O.

Circle No. 241, 242, or 243 on reply card

COMPONENT PARTS



HIGH STABILITY POT

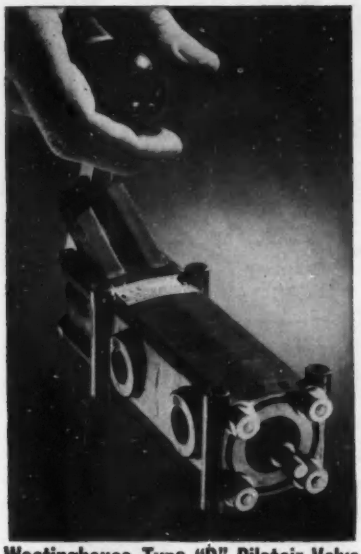
An adjusting screw with zero end play, wire of a known temperature coefficient, and a mandrel with selected expansion characteristics, are combined to provide this new 25-turn wirewound trimming pot with a stability of 60 ppm at temperatures up to 190 deg. C. Production units, vibration tested at 2,000 cps, 100g's in all three axes, showed only 0.1 percent change in resistance setting, with no contact chatter. Overall dimensions are 1.25 by 0.24 by 0.33 in.; resistance range, 100 ohms to 100 K; operating life, unlimited at 100 deg C.—Aero Electronics Corp., Gardena, Calif.

Circle No. 244 on reply card

FOR HIGH PERFORMANCE

Three new synchros, two Size 11 and one Size 8, have been designed to operate effectively over a temperature range of minus 54 to plus 200 deg C. Dimensionally, electrically, and mechanically identical to units in the manufacturer's R900 Series, the Size

Typical Control Functions solved by AIR CIRCUITRY



Westinghouse Type "D" Pilotair Valve

Another of Westinghouse Air Brake's many AIR CIRCUITRY components, the "D" PILOTAIR® Valve is a spool-type directional valve that can be operated by a lever, button, cam, solenoid, air pilot, pedal or treadle. Valves available in two, three, and four-way operation, two and three position, open neutral, lap neutral and vented neutral. Port sizes are ¼" and ½" ips. Operators may be on either or both ends. Max. operating pressure: 250 psi.

DESIGN FEATURES. A new design of seal and segment construction gives the "D" PILOTAIR® Valve increased capacity and requires a minimum of maintenance. By rotating operators, their mounting brackets and any of their ports in 90° steps, over one-hundred thousand combinations may be obtained. They operate in any position with air, gas, water and most oils. The "D" PILOTAIR® Valve can satisfy any of your directional valve needs. For more information, ask for catalogue A4-75.01.

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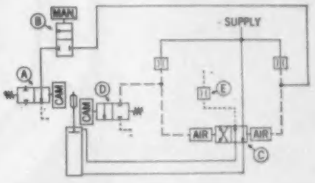
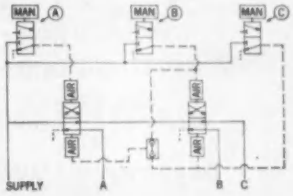
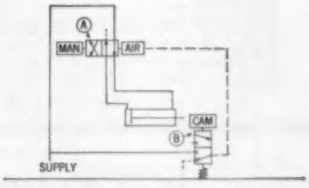


1. AUTOMATIC CYCLING—Supply air flows to the cylinder to extend the cylinder rod and actuate cam operated valve "A." By operating valve "B" air is bled from the right-hand air pilot of valve "C" to operate this device and retract the cylinder rod. This actuates valve "D" and reverses the process. Cycling time may be changed by regulating the FLOREG® valve "E." The stroke is set by moving the cams on the cylinder rod.



2. STATION TRANSFER—Any of the three stations may capture supply air for the station by operating its respective valve. This may be expanded to any number of stations.



3. AUTOMATIC RESET—To reset the operating valve "A" after completion of an operation. Moving the manual operator admits supply air to the cylinder to extend its rod. At the end of the cylinder rod stroke cam operator valve "B" is actuated to connect supply air to the air pilot operator of valve "A." This returns this valve to its original position. Supply air is then connected to the cylinder to retract the cylinder rod. The circuit is now ready for recycling.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor

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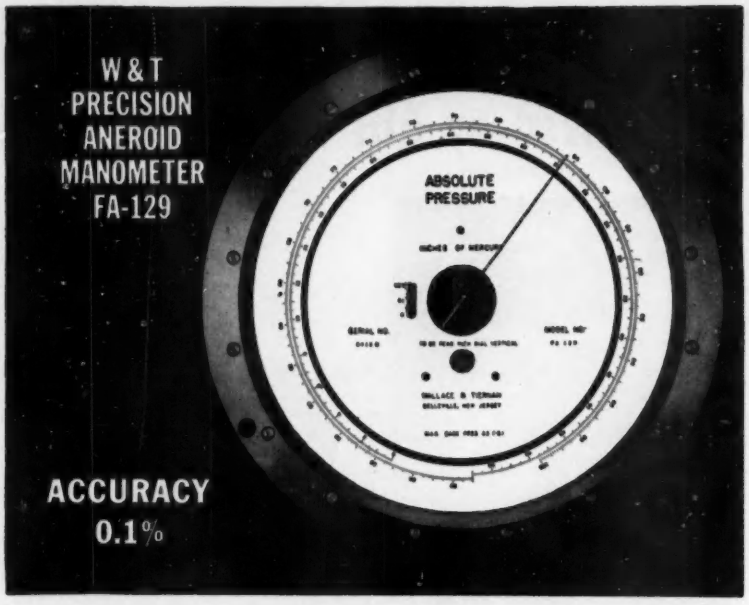
CIRCLE 111 ON READER-SERVICE CARD



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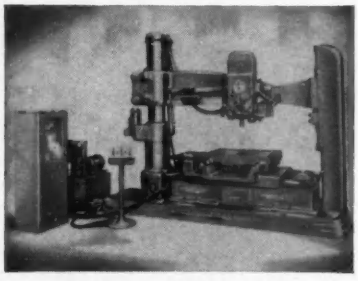
CIRCLE 113 ON READER-SERVICE CARD

NEW PRODUCTS

11 models incorporate more advance temperature resistant parts and impregnating materials. Similarly, the new Size 8 model resembles units in the R1000 Series and is ideally suited for missile applications where space and weight considerations are critical. Both types are designed for 400-cycle operation, and both have a maximum error from electrical zero of 10 min. —Kearfott Co., Inc., Clifton, N. J.

Circle No. 245 on reply card



JIG BORER ACCURACY

Key components of a new automatic machine tool control include a pedestal-mounted control panel, a punched-tape reader, a measuring system of linear electrical scales, and an electrohydraulic positioning system. Photo above illustrates an application in which these components are used to position the table of a radial drill developed by the American Tool Works Co. Accuracy of the control system is within 0.0005 in. on all axes, and considerably better for shorter travels. Depending on the application and machine tool, approach speeds vary from 60 to 200 in. per min. Operating pressure range of the positioning system is from 0 to 750 psi. In operation, the unit draws 350 watts from a 115-v, 60 cps line and requires a 60- to 120-psi air supply at 3 cfm.—Sperry Gyroscope Co., of Canada, Ltd., Montreal, Canada.

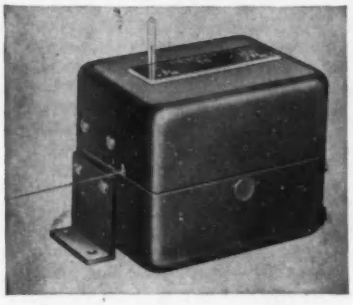
Circle No. 246 on reply card

FOR HIGH-SPEED SWITCHING

Three new drift transistors of the p-n-p alloy type have been designed to handle high-speed switching operations in electronic computers. The 2N643, 2N644, and 2N645 feature a minimum gain-bandwidth product of 20, 40, and 60 mc, respectively. This permits design of switching cir-

cuits having total rise, fall, and propagation time in the order of 20 mμsec.—Radio Corp. of America, New York.

Circle No. 247 on reply card



COMPLETELY MECHANICAL

Priced at $250, this Model 301 mechanical force amplifier can position an 18-oz load with an applied force of less than 0.04 oz. Total useful travel of both output and input is 2.0 in. Unit can be directly actuated by mechanical flow, temperature, or pressure elements, and used to position automatic controls, recording pens, encoders, small valves, etc. An external source of driving power is required.—American Meter Co., Inc., Garland, Tex.

Circle No. 248 on reply card

PLUS . . .

(249) a ⅞-in., 10-turn potentiometer, manufactured by **Spectrol Electronics Corp.**, San Gabriel, Calif., features a type of construction that permits high-volume low-cost production without sacrificing precision. . . . (250) **Wiltec Electronics, Inc.**, South Norwalk, Conn., recently introduced a **Dual-Control Indicator Tyratron** that produces a bright neon indicating glow whenever two coincident signals are applied to its control grids.

Circle No. 249 or 250 on reply card

ACCESSORIES & MATERIALS

POTTING COMPOUND

Cepox 501 and 502 are two new thermosetting, low-viscosity epoxy liquids that exhibit excellent electrical, physical, and chemical properties. The first is a rigid general-purpose material; the second, a high impact resistant material for applications involving

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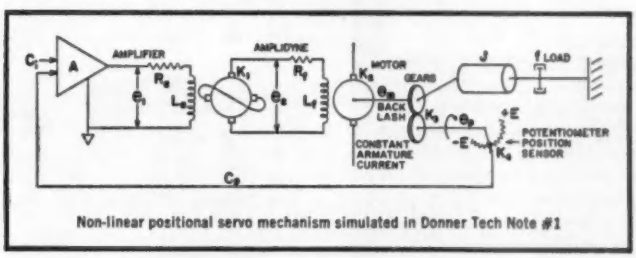
computer tech notes

News about

- *Computer applications
- *New methods of simulation
- *Application of new feedback design techniques
- *Analog control systems

Your free copy of Donner Tech Note #1 is ready now.

Lead article in the first issue is titled "How to simulate a non-linear control system with an analog computer." A step by step analysis takes you through the intricacies of setting up a Donner analog computer to simulate a non-linear positional servo mechanism.



Non-linear positional servo mechanism simulated in Donner Tech Note #1

By simulating the system on the computer, the designer can examine system performance under the influence of every parameter. Changing constants and observing changes in response gives the designer a feel for the system impossible with a strict analytical approach.

Donner Tech Note #1 contains complete photos and diagrams showing the solution to this problem. For your copy, call your nearby Donner engineering representative or write Dept. 087

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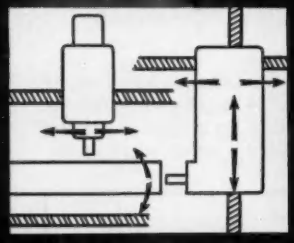
The same mechanism that controls the horizontal tail may improve your machine tool



The G. & L. and Hypro Div. of the Giddings & Lewis Machine Tool Co. uses 4 Beaver Ball screws (up to 16′ long) per machine for automatically positioning heads and swiveling the work chuck of their numerically controlled skin mills—shown here machining wing skin for a jet fighter aircraft.

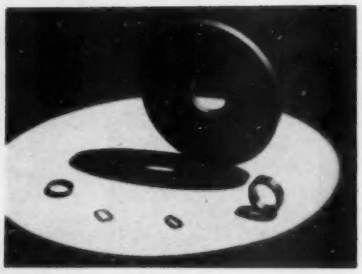
Our engineers are available to discuss machine design problems with you.

Beaver Precision Products INC.
CLAWSON, MICH.

CIRCLE 115 ON READER-SERVICE CARD

temperature cycling and high mechanical shock.—Chemical Development Corp., Danvers, Mass.

Circle No. 251 on reply card



IDEAL FOR CORES

MN-30, a new highly-permeable, highly-machinable ferrite, can now be supplied in virtually any size or shape with dimensional tolerances of plus or minus 0.001 in. Its low losses and high saturation magnetization make the material suitable for applications at frequencies up to 500 kc.

Characteristics:

Maximum permeability: 6,000 at 2,000 gausses
Flux density: 4,250 gausses at 7 oersteds
Retentivity: 1,300 gausses
Coercivity: 0.13 oersteds
Loss factor at 50 kc: 7.5×10^{-6}
Curie temperature: 180 deg C
—Kearfott Co., Inc., Clifton, N. J.

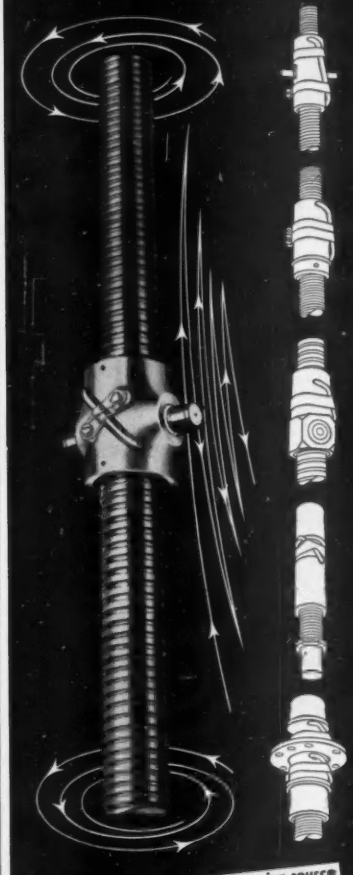
Circle No. 252 on reply card

PORTABLE SAMPLER

Low power requirements, high efficiency, compact size, and light weight enhance the design of this new effluent sampler. Ideal for use in chemical and allied industries, the instrument features a fractional-watt dc motor

beaver ball screws

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficiency in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments to massive wind tunnel jacks. Any diameter or travel: indexing, inching, traversing. Literature, consulting engineering service available.



Fastest growing source for ball screws

Beaver Precision Products INC.
CLAWSON, MICH.

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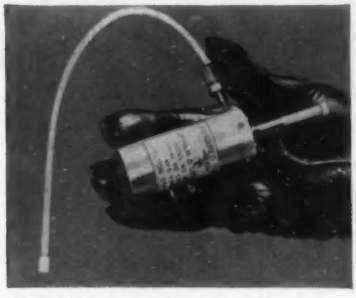
that will operate for 3-4 months on three No. 6 dry cell batteries, and delivers a continuous sample at the rate of ½ gph. Its self-priming pump will suction lift up to 10 ft.—Brailsford & Co., Rye, N. Y.

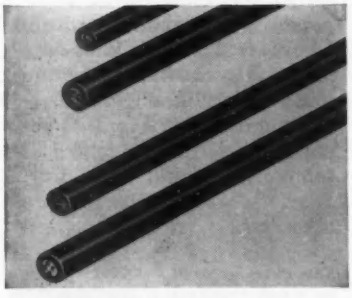
Circle No. 253 on reply card



COOLS IR GEAR

The ADL min-IR-cooler, pictured above, is a tiny, low-pressure, closed-cycle, refrigeration device that super-chills infrared detection equipment to minus 350 deg F. In operation, helium expands from 300 psi in a ¼-in. by 2 in. long cylinder. A small plastic piston is the only moving part of the unit below room temperature. Purpose of the device is to increase sensitivity of IR detection equipment.—Arthur D. Little, Inc., Cambridge, Mass.

Circle No. 254 on reply card



NEW T'COUPLE WIRES

Available in 12 standard constructions, these new thermocouple wires have been designed to withstand ambient temperatures of over 2,000 deg F. Inconel sheathing protects the wires against moisture, oils, ozone, and solvents; selected crystalline magnesium oxide, compacted to maximum density, provides the insulation.—Revere Corporation of America, Wallingford, Conn.

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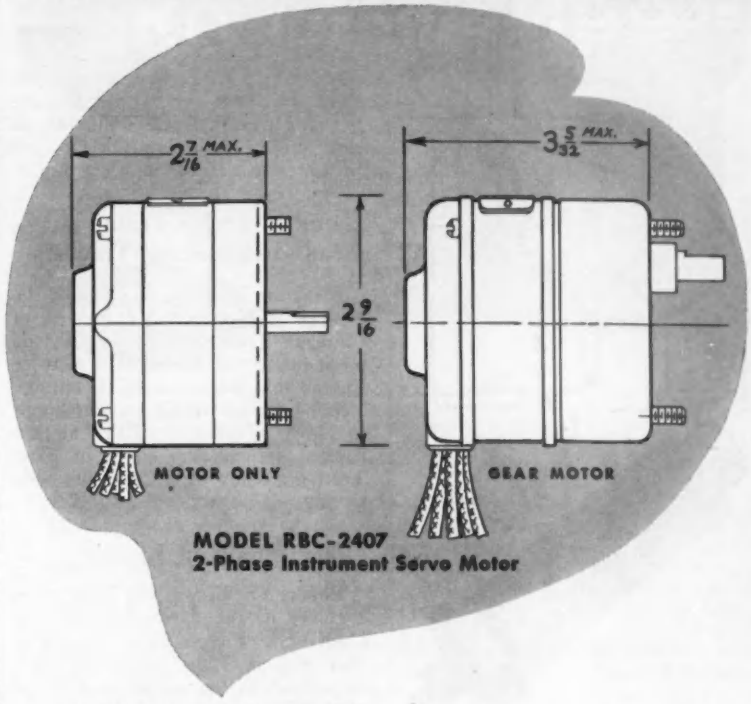
HOLTZER-CABOT
offers these CUSTOM FEATURES in a new stock motor



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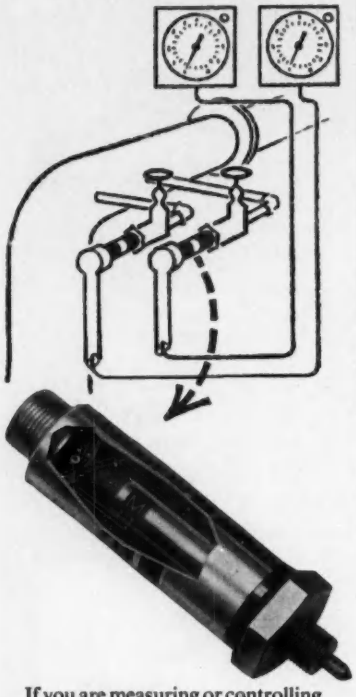

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WHAT'S NEW

MOVES BY KEY PEOPLE

(CONTINUED FROM PAGE 60)

Genesys Corp., the fairly young Los Angeles manufacturer of digital process control computer systems. He will head a group of process and computer specialists in the Engineering Dept. who will work closely with Genesys' customers in determining control requirements and system instrumentation for pipelines and refineries. A joint project with Sun Oil Co. has already been assigned to the group.

Carnegie Tech's Teare Heads Engineering Teachers

Benjamin R. Teare Jr., dean of the College of Engineering & Science of Carnegie Tech, will be installed as president of the American Society of Engineering Education at the annual meeting of the ASEE in Pittsburgh the 15th to the 19th of this month. Elected via national ballot in May, Teare is a fellow of IRE and has been serving as vice-president of ASEE.

Other Important Moves

Robert O. Briggs, the new chief engineer of the Electronics Div. of United ElectroDynamics, Inc., comes from Robert Briggs Associates, Inc., consultants in the analysis and design of missile guidance and control systems and instrumentation systems. Under Briggs, United ElectroDynamics will shape its plans for an eventual diversification into automatic control and industrial instrumentation. Its present area: applied research, flight electronics, missile-test-range instrumentation, and industrial electronics.

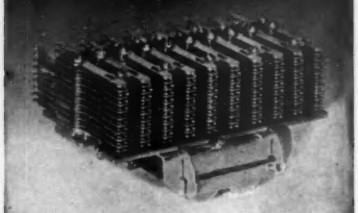
Director of engineering is the new title of Arnoux Corp.'s **Donald J. Gimpel.** He was director of research.

Raytheon Co. has named **Osmund T. Fundingsland** director of research, a new position. To take it, Fundingsland left Sylvania Products, Inc., where he had been manager of the Microwave Physics Laboratory at Palo Alto, Calif., since 1956. He joined Sylvania in 1953, has also been with the radiation laboratories of MIT and the University of California, and Air Force's Cambridge Research Center.

Stanley J. Rado is the new chief engineer of American Electronics' Instrument Div. at Culver City, Calif. Formerly assistant chief engineer of Kearfott Co., Inc. Rado will be responsible at American Electronics for the design and d velopment of its servo

STROMBERG-CARLSON

"BB" Series Relays



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components. (The company has just formed an American Data Div. in Brooklyn, N. Y., to handle its peripheral data processing equipment.)

Roger Newman now heads the Physics Dept in the Materials Research Laboratory of the Hughes Products Group's Semiconductor Div., a Hughes Aircraft Co. unit. He was formerly with General Electric Co. New managers in the Products Group are **Clayton E. Murdock** (engineering) and **George F. Wunderlich** (operations), both formerly with Eitel-McCullough, Inc. **Thomas D. Hanscome,** formerly with the Navy Research Laboratory, and **Walter G. Wadey,** formerly a physicist at Yale University, are recent arrivals at Hughes' Nuclear Electronics Dept.

William A. Mussen, formerly chairman of the Electrical Engineering Dept. of Southwest Research Institute, has been named chief development engineer for Singer-Bridgeport, a facility of Singer Mfg. Co.'s Military Products Div.

RCA has appointed **Frank E. Vaccaro** manager of microwave advanced development in the Electron Tube Div. at Princeton, N. J. He has been with RCA since 1949, most recently as an engineering leader in the MAD group, of the Princeton division.

Veet Industries of East Detroit, Mich., builder of special-purpose machine tools, precision radial drills, and milling heads, has named **Charles Peterson** chief engineer. A machine designer, Peterson most recently was with Futurmill, Inc., manufacturer of cutters, milling machines, and spindles, has also been with Walter Engineering Co., Snyder Tool Co., Arthur Colton Co. and Tuscan Design Co.

Granger Associates has advanced **Stuart R. Hennies,** a senior member of the engineering staff since 1957, to chief engineer. Before joining Granger, he was with Varian Associates.

Paul Winsor III, well-known for his contributions to the electronic-computer field, has been named associate director of engineering of Auerbach Electronics Corp. He formerly was staff technical consultant at the Burroughs Research Center, where he worked on the Atlas guidance computer, a solid-state device.

Eugene B. Novikoff, who joined Instruments for Industry, Hicksville, N. Y., in 1952, has been raised from director of engineering, a position held since 1957, to vice-president for engineering. He has also been IFI's supervising engineer and chief engineer.

The new chief engineer of the In-

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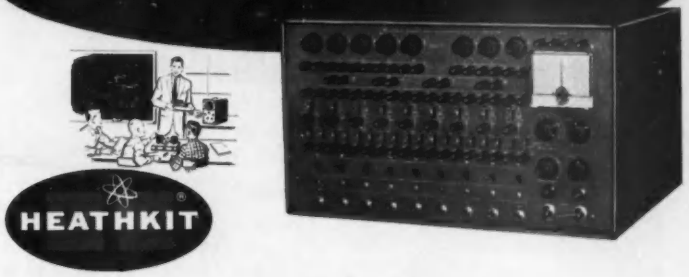

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Industry will find the EC-1 invaluable in trial solutions to mechanical and mathematical problems . . . shortens engineering time, speeds up preliminary work, frees the advanced-computer time for more complex problems and final solutions. And the EC-1 aids in training computer operators and acquainting engineers with computer versatility and operation.

Schools and *colleges* will find the EC-1 ideal for teaching and demonstrating in engineering, physics, and math classes; perfect for laboratory use in teaching computer design and applications.

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Set up scores of complex problems with the assortment of precision components and patch cords supplied. Read problem results directly on the 3-range computer meter, or use an external read-out device such as the Heathkit OR-1 DC Oscilloscope, or a recording galvanometer. Meter can be switched to read output of any amplifier for problem results or balancing purposes. Informative manuals provided show how to set up and solve typical problems, illustrate operating procedures, and supply basic computer information, references, and construction procedure. Shpg. Wt. 43 lbs.

SPECIFICATIONS: Amplifiers: 9 D.C. Operational Amplifiers using one 6U8 per amplifier; each solves mathematical problems; each balanced by individual panel control without removing problem set-up. Computing components mount on connectors and plug into panel sockets. Open loop gain approximately 1000. Output —60 to +60 volts at 3 ma. **Power Supplies:** +300 volts at 25 ma electronically regulated; variable from +250 to +350 by control with meter reference for setting +300 volts. Negative 150 volts at 40 ma regulated by VR tube. **Coefficient Potentiometers:** Five on panel. **Initial Condition Potentiometers:** Three on panel; used to introduce initial velocity, acceleration, etc. on the three "given" quantities. **Repetitive Operation:** Multivibrator cycles a relay at adjustable rates (.1 to 15 CPS), to repeat the solution any number of times; permits observation of effect on solution of changing parameters. **Meter:** 50-0-50 ua movement. **Power Requirements:** 105-125 volts, 50-60 cycles, 100 watts. **Dimensions:** 19¼" W. x 11⅞" H. x 15" D.

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WHAT'S NEW

dustrial Div. of Cubic Corp., San Diego, is **James G. Tabler,** formerly senior staff engineer with the associate director of engineering. One of Tabler's duties will be to oversee two new teams of engineers, one doing product R&D and the other consultation work on unique customer requirements. He was most recently a project engineer at Cubic.

Vice-president of engineering, a new position at Kollsman Instrument Corp., has been filled by **David B. Nichinson,** formerly director of R&D and a 14-year man with Kollsman. He came to the company in 1945, from MIT's Radiation Laboratory.

William D. Macgeorge, the new chief engineer of Tatnall Measuring Systems Co., comes to The Budd Co. subsidiary from Automatic Timing & Controls, Inc., where he was director of research and engineering.

CBS Laboratories has picked **Nicholas Fuschillo,** formerly head of the Magnetics & Semiconductor Branch of Franklin Institute, to head the Solid State Physics Dept. His principal interests are thermo-electricity and nuclear magnetic resonance. **Alfred E. Kaspaul,** with CBS Labs since 1957, was named technical manager of the Solid State Physics Laboratories.

Chief Engineer **Louis Berni** of Ace Electronics Associates, Inc., Somerville, Mass., has been named vice-president for engineering. Berni has been with the New England potentiometer manufacturer since 1952, when it was formed.

The new vice-president for engineering of Teleregister Corp. is **Alexander Greenfield,** formerly vice-president of Fischer & Porter Co. and before that director of R&D for Daystrom Instrument Company.

A new Silicon Transistor Group in the Semiconductor Div. of Hoffman Electronics Corp. is being managed by **Norman V. Golden,** formerly in charge of semiconductor operations and product development for Sylvania-Thorn, Ltd., of England.

The Garrett Corp. has made several import promotions in AiResearch personnel in Los Angeles and Phoenix, Ariz. They involve: **James V. Crawford,** now chief engineer at Los Angeles; **Norman M. Brown,** assistant chief; **Helmut Schelp,** chief engineer at Phoenix; **Carl Paul,** assistant; and **C. F. Blanding,** engineering manager at Phoenix.

William F. Miller, who has been active head of the Applied Mathematics Div. of Argonne National Laboratory since last July, now holds that office officially.

BULLETINS AND CATALOGS

(300) "HOT" MATERIALS HANDLING. Mechanical Div., General Mills, Inc. 20-page brochure. Describes the organization, facilities, products, and services of the Mechanical Division's Nuclear Equipment Department. Line drawings and specifications cover a complete line of remotely controlled handling devices, including mechanical arms, cutting equipment, hoists, control rod drives, and automatic controllers.

(301) IR DETECTORS. Infrared Industries, Inc. Technical Bulletin 2, 12 pp. Provides the infrared system designer with a complete description of the types and performance characteristics of Infratron lead sulfide detectors. Of particular interest is a series of curves that can be used to determine optimum signal, s/n ratio, noise-equivalent power, or responsivity, for any given set of operating conditions.

(302) ANALOG COMPUTER SPECS. E.M.I. Electronics, Ltd. 28 pp. Contains complete technical specifications on all major components of the EMIAC II analog computer. Circuit drawings and actual photos of the patch panel illustrate patching techniques for summing and reversing, integration and multiplication. A full page is devoted to each of six typical applications, and covers the problem, its mathematical model, use of the computer, and the results obtained.

(303) FOR SERVOSYSTEMS. American Measurement & Control, Inc. Catalog C-2, 6 pp. Briefly describes a line of components and instruments designed for use in the operation or testing of servos. Included are: servovalves, flowmeters, torque motors, current bridges, phase shifters, and amplifiers.

(304) TRANSISTORIZED TAPE UNIT. Precision Instrument Co. Bulletin 55, 8 pp. Features a 2-page listing of the mechanical, electrical, and general specifications of the PS-200 instrumentation magnetic tape recorder. Other sections describe its transistorized electronics and standard accessories.

(305) TEST INSTRUMENTS. California Technical Industries Div. of Textron, Inc. 1959 Short-Form Catalog, 12 pp. Equipment for automatic circuit testing, antenna testing, and flight simulation is presented here. Complete price list follows the descriptive material.

(306) PRESSURE SWITCHES. Barksdale Valves. Catalog PS-59-60, 36 pp. Each page covers a specific type of pressure switch (diaphragm, bourdon tube, or piston) with details on the electrical and operating characteristics, adjustment instructions, an exploded isometric drawing, and a dimenison diagram.

(307) THERMOWELL LINE. Trinity Equipment Corp. New catalog lists and describes a variety of thermowells and fittings for use with thermocouples. Both bar-stock and built-up types are shown.

(308) FEED WATER CONTROLS. Bailey Meter Co. Bulletin 530, 8 pp. Reviews the operating principles and advantages of a 3-element feed-water control

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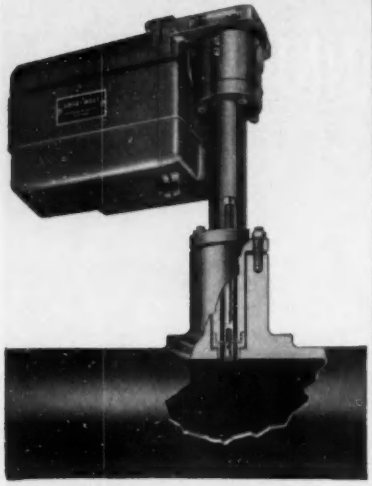

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system. Illustrations include flow diagrams, photos of typical installations, and circular-chart records of performance.

(309) GAS FLOWMETER. National Instrument Laboratories, Inc. Bulletin 178, 4 pp. Lists practical design features of a new primary element for measuring the mass flow of gases. One drawing shows how a valve assembly may be added to provide higher sensitivity where line pressure is maintained at a continuous high-pressure level.

(310) RADIOISOTOPES IN CONTROL. Highlights applications of radioisotope measurements in chemical, food, paper, petroleum, and other industries; and describes a number of nuclear gaging systems for sensing density of fluids or thickness of solids.

(311) TINY TOGGLE SWITCH. Micro Switch Div. of Minneapolis-Honeywell Regulator Co. Data Sheet 158, 2 pp. Photos and dimension drawings accompany complete descriptive information on a new miniaturized toggle switch that weighs only 4½ grams.

(312) AIRCRAFT VALVES. Koehler Aircraft Products Co. Bulletin C-591, 12 pp. Offers specifications, operating characteristics, and application data on a line of aircraft valves, strainers, filters, etc. A "Selector-Index" relates valve functions and material to be handled, to the appropriate valve type.

(313) SELENIUM RECTIFIERS. Rectico, Inc. 8-page bulletin. Devotes a full page to general design information, showing six common circuits and the connections required for different types of stacks. Other tables cover current and voltage ratings, temperature derating, and overloads.

(314) FLUID POWER UNITS. Lear Grand Rapids Div. Product Data Sheets 106-3 and 106-4, 2 pp ea. Contain general description, performance curves, and engineering data on two new hydraulic power units for 3- and 5-hp applications.

(315) DC AMPLIFIER. Minneapolis-Honeywell Regulator Co. Catalog B-C2HLA-4, 4 pp. Includes an interesting presentation on the inputs and outputs that can be handled by a new dc amplifier with an isolated dieffrential input. Chart provides detailed performance specifications.

(316) MOISTURE MONITORS. Consolidated Electrodynamics Corp. Bulletin 1834C, 8 pp. Deals with the operation and application of two new portable instruments for monitoring or controlling the moisture in gases or gaseous mixtures. Additional photos illustrate standard accessories.

(317) HIGH-VOLTAGE SUPPLIES. Del Electronics Corp. 4-page bulletin. Describes a new line of compact, high-voltage power supplies designed specifically for CR oscilloscopes, electrostatic precipitation equipment, radar displays, dielectric insulation testers, etc.

(318) WORD INDICATOR LIGHTS. Master Specialties Co. 16-page brochure. Introduces the Roto-Tellite line of rotat-

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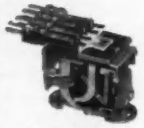

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ing word indicator lights for visual display of operating conditions. Sketches show how these panel-mounted units can be rebulbed from the front end, with no tools whatsoever.

(319) TEMPERATURE ELEMENTS. Bailey Meter Co. Product Specification E51-6, 4 pp. Illustrates the Pyrotron line of temperature sensing units. Shows how a completely integrated assembly – from resistance element to connection head– provides faster response and more accurate results.

(320) SILICONES. General Electric Co. Catalog CDS-129A, 8 pp. Highlights the benefit of using silicones in a variety of industrial applications. Also lists other catalog numbers for more specific information on each of the materials described.

(321) ROTARY COMPONENTS. Clifton Precision Products Co., Inc. Catalog SC-3-59-10M, 26 pp. Gives complete electrical and mechanical characteristics for a wide line of rotary servo components. These include: all types of synchros, sizes 8 through 22; servomotors and motor-generators, sizes 8 through 11; precision computing resolvers; and linear transformers.

(322) RELAY TESTER. Mid-Eastern Electronics, Inc. 2-page bulletin. Quickly reviews the operation and use of a new automatic relay tester designed to determine the pull-in and fall-out characteristics of relays on a production-line basis.

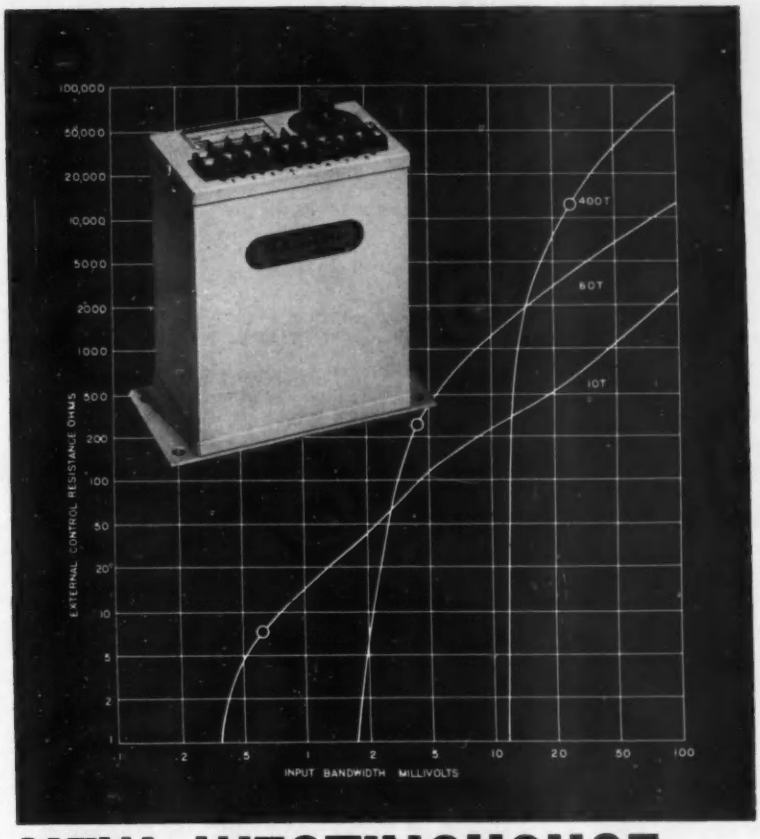
(323) PRESSURE CUTOFF. Datex Corp. Bulletin No. 103, 2 pp. Photo, wiring diagram, and dimension drawings help to describe the PE-103 Pressure Cutoff, a compact device that provides On-Off switching of up to 30 pressure points simultaneously.

(324) INDICATING CONTROLLER Fenwal Inc. Bulletin MC-176, 4 pp. Provides complete details on the Series 541 temperature indicating controller. Selection charts list available types of controller housings and actuator assemblies.

(325) BUTTON CELLS. Gulton Industries, Inc. Bulletin No. VO-110. Highlights, the features, design potentials, and specifications of the VO-Series, nickel-cadmium, button-cell battery line, which includes more than 50 distinct sizes and voltages. Typical cell discharge curves show voltage changes as a function of capacitv for different discharge rates.

(326) MOTOR SELECTION. Reliance Electric & Engineering Co. Bulletin B-2103-4, 12 pp. Offers concise selection data on ac motors from 1 to 200 hp. Includes brief explanation of NEMA design classes, speed-frequency relationship, current and torque values, as well as frame selection tables and complete dimension information.

(327) STABLE VOLT-AMMETER. Keithley Instruments, Inc. Engineering Notes, Vol. 7, No. 1, 4 pp. Features the Model 150 Micro Volt-Ammeter for measuring voltages as low as 0.03 mv and currents down to 2 μ amp. Included are a detailed description of the circuit design and actual reproduction of stability tests.



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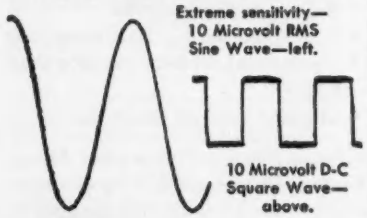

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Bulletins & Catalogs

(328) CONTINUOUS ANALYSIS. Technicon Controls, Inc. Brochure, 8 pp. Shows how the AutoAnalyzer system for continuous chemical analysis can be used in the laboratory as well as on stream in the plant. Also gives a complete description of the various system components.

(329) STRAIN-GAGE DATA. Baldwin-Lima-Hamilton Corp. Specification and price list 4310, 24 pp. Contains complete electrical and physical specifications on a wide variety of bonded-wire strain gages and accessories.

(330) LEVEL CONTROL. Robertshaw-Fulton Controls Co. Technical Bulletin RF 5910, 4 pp. Illustrated brochure deals with the Level-Tek level detection and control system. Dimensional drawings show types of enclosures available.

(331) HYDRAULIC ACTUATORS Dalmo Victor Co. Booklet, 15 pp. Entitled "Design Data for Hydraulic Servo Actuators", this handy reference discusses characteristics of direct-coupled rotary, commutating rotary and linear types of actuators. Included are seven design nomographs that simplify selection of actuators for particular applications. Four pages describes their use.

(332) INSTRUMENT BEARING CARE. Miniature Precision Bearings, Inc. Reprint No. 5810, 26 pp. Deals with the lubrication of miniature ball bearings used in instruments and other applications. Reviews the variables that affect lubrication and tabulates the characteristics of various oils and greases. Considerable space is devoted to MIL spec lubricants.

(333) MANOMETER DATA. Dynametrics Corp. Brochure, 8 pp. Explains the principles and terminology used in manometry and contains well-illustrated sections on the different types of manometers and their application.

(334) FUNCTION GENERATOR. Navigation Computer Corp. Engineering report, 12 pp. Subject of this report is a digital controlled function generator. Block diagram accompanies a general description, while more detailed drawings illustrate discussions of the time-marker section, the function-select-and-generator section, and the function-programming sequence.

(335) COAXIAL CABLE. The Boston Insulated Wire & Cable Co. Bulletin, 4 pp. Lists physical and electrical characteristics of a complete line of miniature coaxial cable for military and commercial applications.

(336) CENTRALIZED CONTROL. Protection Controls, Inc. Bulletin No. 159, 4 pp. Illustrates various custom-engineered control panels for a wide range of functions in different industrial applications. Cites advantages of centralized control.

(337) MILLIVOLTMETERS. Industrial Div. of Minneapolis-Honeywell Regulator Co. Catalog C10-1, 28 pp. Covers operating principles, specifications, and ordering information on a variety of millivoltmeters. Indicating, controlling, and safety-cutoff types are included. Last seven pages deal with primary and final control elements and a number of accessories.

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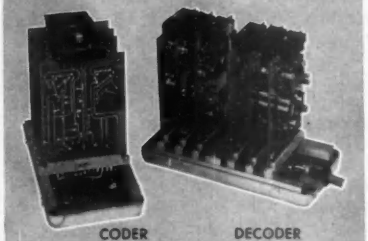

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ABSTRACTS

Frequencies to 1 cpm

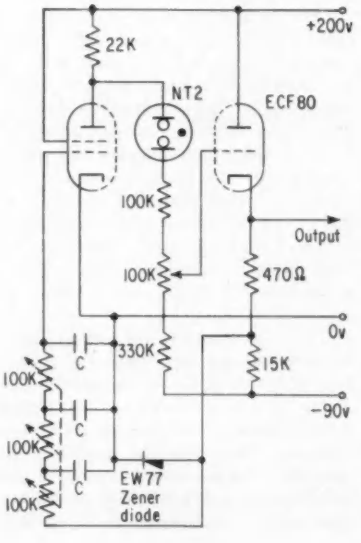
From "A Simple, Very Low Frequency Oscillator" by J. F. Young of the General Electric Co., Ltd., Birmingham, England. "Electronic Engineering" Vol. 31, No. 374, April, 1959, p. 218.

Vacuum-tube oscillators with R-C selective circuits require some type of amplitude limitations for two reasons: to maintain a constant output voltage, and to minimize harmonic distortion. The techniques generally used, however, are frequency sensitive.

Automatic gain control, for example, presents difficulties when the oscillator must cover a wide frequency range, while thermal nonlinear elements not only create an ambient temperature problem but also cause response to instantaneous rather than rms amplitudes at very low frequencies.

One possible solution lies in the use of an amplitude limiter or clipper, combined with a selective circuit designed not only to control the output frequency but also to filter out harmonics produced by the clipping circuit. For such a selective circuit, multiple-ladder networks have been found to give much better results than the commonly used Wien bridge or parallel-T networks. A typical multiple-ladder network used in conjunction with the clipped wave might have a third-harmonic distortion as low as 1 percent of the fundamental.

The accompanying schematic is of an oscillator design based on this ap-



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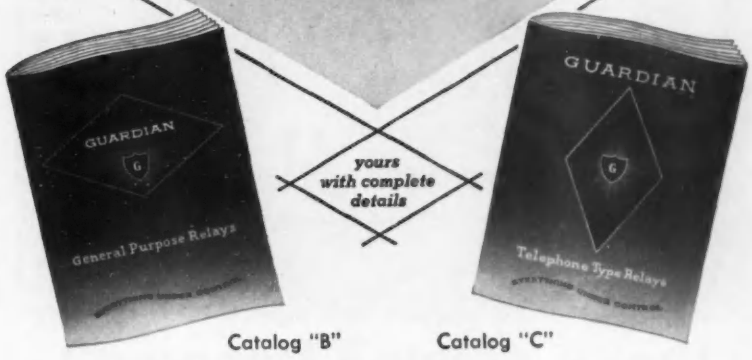

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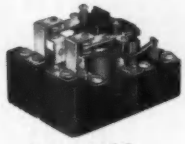
The appearance of new Guardian catalogs is always greeted with eager anticipation by the world's most critical users of electromagnetic controls. For Guardian relays traditionally express the fullest measures of progress in relay engineering, design, and highly reliable performance. Now—the news about Guardian General Purpose and Telephone Type Relays commands the attention of those whose responsibility it is to specify or buy the most applicable relays. Completely detailed information portrayed in these catalogs will guide your selection with accuracy. We invite you—request Guardian Catalogs "B" and "C" on your business letterhead.



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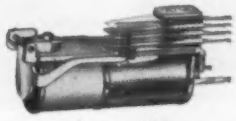

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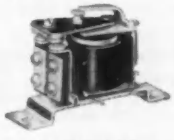

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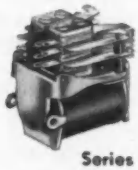

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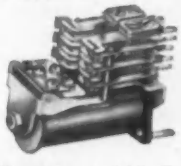

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proach. The circuit uses an ECF80 triode-pentode as an amplifier and cathode follower. An EW77 Zener diode clips the waveform and, at the same time, provides an effective bias for the pentode section. Output of the circuit is about 12 volts peak-to-peak with a reasonably low output impedance. Oscillation starts without difficulty and there are no transient effects while tuning.

Range of the circuit is from 100 kc to 1 cycle per min. Stray capacitance imposes the upper limit while the physical size of the capacitors required determines the lower one.

An improved version of this basic circuit might involve the use of a four-gang tuning resistor, or, preferably, capacitor, and an extra cathode-follower to reduce the source impedance seen from the selective circuit.

New Ferrite May Simplify Designs

From "A New "Square-Loop" Ferrite and its Potential Fields of Application" by B. R. Budney, Allen Bradley Co. Paper prepared for presentation at the 1959 Electronic Components Conference, Philadelphia, Pa., May 6-8, 1959.

A recently developed ferrite material possesses high maximum saturation flux density, low coercive force, a high ratio of residual to maximum flux density, and a short switching time. Its specific losses per cycle of operating frequency are very low at a temperature of 25 deg C, and actually decrease with further increase in temperature, up to about 100 deg C.

One application is in the design of transformers for symmetrical square-wave voltage pulses at a duty cycle of less than unity, where minimum backswing under light loading is desired. The characteristics are also excellent for high-frequency magnetic-amplifier applications involving supersonic frequencies. Other potential applications are in the computer field (shift registers and logic devices). Medium- to high-power switching applications, where rapid transition is desired, would also benefit.

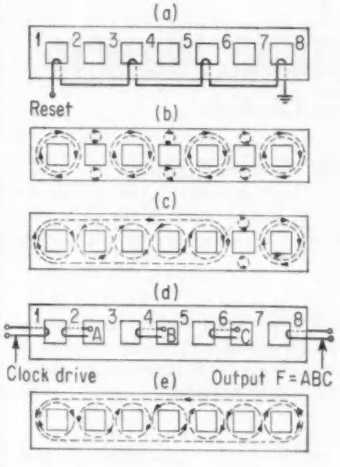
This new ferrite is not a coincident-current memory core material, for irreversible changes in magnetization occur at lower relative disturbing fields. However, it has a much higher operating flux density and a considerably lower coercive force compared to typical 1-microsec switching time coincident-current core material.

The design of dc-to-dc converters and dc-to-ac inverters is simplified and the operating frequency can be of the order of 50 kc. Here, the high residual flux density results in very low voltage spikes during switching periods.

Logic With Tiny Ladders

From "The Laddic—A Magnetic Device for Performing Logic" by U. F. Gianola and T. H. Crowley, both of Bell Telephone Laboratories. "Bell System Technical Journal" Vol. XXXVIII, No. 1, January 1959.

A new magnetic memory and switching device reecntly developed at Bell Labs has been named the Laddic. It consists of a miniature ladder-like structure cut from small pieces of ferrite having a rectangular hysteresis loop. Sides of the "ladder" and all of its "rungs" have the same minimum cross-section, so that all possible paths are flux-limited. Such a structure presents a large number of possible flux paths. By controlling the actual switching path through the structure, any Boolean function of *n* variables can be produced.



This paper discusses a number of operating modes and presents both design formulas and experimental results. The drawing above (authors' Figure 5) illustrates the operation of the Laddic as an AND gate. After the reset winding (shown only in a) is pulsed, the flux pattern will appear in a number of forms (such as at b or c). However, the direction of magnetization of the rungs will be the same. Now if a current pulse is ap-

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Union Switch & Signal makes two types of electro-mechanical, DC-operated readout instruments, displaying 10, 12, or 16 characters on a wheel; or displaying up to 64 characters on a MYLAR* belt. Character assignments can be furnished as required.

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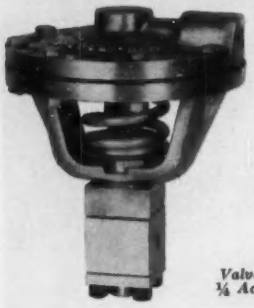

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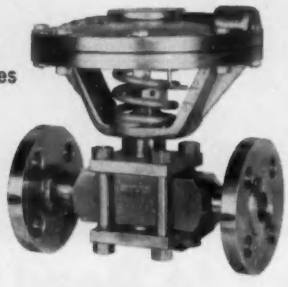

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Temperature Rating	−70°F to +450°F	−70°F to +450°F (750°F with finned bonnet)
Maximum Cv.	0.63	10.0 (1" connections)
Lift	¼"	7/16"
Seat Area	0.038 sq. in.	up to 0.601 sq. in.
Connections	⅛", ¼", ½" N.P.T. Standard (others available)	¼" to 1" N.P.T. ½" to 1" flanged

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ABSTRACTS

plied to rung 1 in a direction to switch flux down, the flux return will be through the closest available path, i.e., through rung 2. But if input variable *A* is present on rung 2 and adding to the downward flux, rung 2 will not be available. Rungs 3, 5, and 7 are saturated upwards and likewise not available. If input variables *B* and *C* are also present and hold flux downward, rungs 4 and 6 become unavailable. Then only rung 8 is available for flux return to rung 1, and an output will result. The flux pattern with inputs *A*, *B*, and *C* present is shown in *e*.

Operating currents in this device are not critical; thus, it can be operated at speeds limited essentially only by the current drives available. Output may be taken during the input variable phase or during a subsequent reset phase. Switching speeds of a few tenths of a microsecond and repetition rates of a few hundred kc have been produced.

Excerpts From NACA Report

From the "Forty-fourth Annual Report of the National Advisory Committee for Aeronautics—1958" NACA Headquarters, Washington, D. C. (Final report.)

The following excerpts, taken verbatim from the committee's administrative report to Congress, cover some of the recent NACA activities in the fields of automatic control and instrumentation. Ed.

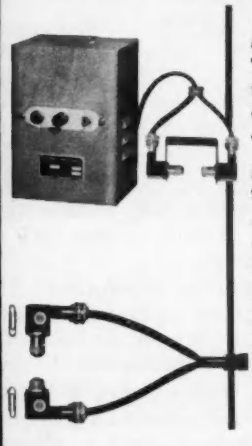
Missiles . . .

Studies of missile stabilization and control have considered improved means of simplifying and analyzing complex automatic control and guidance devices. Although this program was initiated with reference to air-to-air attack missiles, the results have application to other classes of missiles, including ballistic and antiballistic, as well as to automatically controlled and guided airplanes. Some of these studies are discussed now.

Changes that occur in missile response characteristics to control deflections for varying flight conditions have led to complicated methods of adjusting automatic control parameters. In studying a number of simplifying techniques, consideration has been given to a control actuator whose torque output is proportional to the input of the control system.

POST DECITRON ELECTRONIC PRODUCTS

Photoelectronic Controls



Model K-1 with Miniature Photohead

This is a general purpose photoelectric control whereby the interruption of a light beam in the photohead closes a relay which can be used to activate an external circuit.

Model K-3

The K-3 control differs from the K-1 in that the output relay will not energize for each interruption of the light beam, but only if interruptions cease. Can be used to detect "flow" stoppage.

Model H-21-C

The compact, long life, *miniature* photohead . . . ideal for mounting in limited space. May be furnished with alignment brackets to insure proper relation of light source and receiver.

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Results indicate that such actuators can simplify the system and result in acceptable target-miss distances.

A study has been made to determine the relative importance of factors that place limitations on the minimum obtainable miss distance for a missile navigation system in which the missile follows a radar beam that is tracking the target. The factors considered were the natural motions, and steady-state acceleration capabilities of the missile, target evasive maneuvers, and radar angular scintillation noise. Simple correlation equations expressing minimum miss distance in terms of these factors were obtained. Possibilities for system improvements were indicated. Also studied were the effects on the average target-miss distance of limiting the allowable acceleration of a beam-rider missile. Contrary to intuitive thinking, the study showed that miss distance decreased as the ratio of the limiting to the design acceleration increased when the guidance system was designed for best performance at a given acceleration.

The determination of optimum radar-noise filtering characteristics to be used in weapon system design is generally a long and tedious process. Studies of these complex equations have been successful in determining simplifications and approximations to enable sufficiently accurate explicit solutions. From these results it has been possible to answer in a quantitative manner important questions regarding the effect of the target maneuver on the effectiveness of the guidance system.

Other work on improving missile systems indicated the need for enlarging the scope of filter theory to include nonlinear conisderations. This is due to the trend of potential targets to fly at higher speeds and altitudes where the maneuverability advantage of the defensive missile is lost. Under these circumstances present theory is inadequate because the problem becomes a nonlinear one. A study was undertaken to generalize previous theory by exploiting the intentional use of nonlinearities as a means of minimizing miss distances.

Present theory dealing with noise contamination is restricted to systems whose design constants do not vary with time of flight. However, many systems have time-varying constants. Studies have been carried out to enlarge the scope of the theory so as to be applicable to these systems. Factors considered were target evasive maneuver, radar glint noise, missile maneuverability, and the inherent time-varying character of the missile maneuvers. The results of this and

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ITT STORASCOPE TYPE BLS-218

. . . for recording non-recurring events

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- Long storage period
- Short erasing time
- Manual or self-advancing position
- Automatic contrast adjustment
- Low cost CRT

APPLICATIONS

This instantaneous all-electronic recorder is designed for useful application in the investigation of technical problems in such fields as RESEARCH, TESTING, COMPUTING, ACOUSTICS, and MEDICAL ELECTRONICS, where the recording of non-recurring events (periodic or non-periodic) is of particular interest.

FEATURES

The data are recorded on a special dark trace Cathode Ray Tube by purely electronic means and can remain visible for several days or can be erased at any time within a matter of 20 seconds. The viewing area can be used for a single phenomenon, suitably amplified, or can be subdivided through a stepped position control to record up to 10 different waveforms. If so desired, this control may be set to "AUTO" and the trace will be shifted automatically by approximately one centimeter with each new trigger signal. When a special low erasing signal is applied to the screen, the recordings will be continuously erased so that the top line is usable again as soon as the last line is completed.

X-Y PLOTTING

Since the horizontal sweep can be replaced by an external voltage, the Storascope can be employed for x-y plotting.

NO SPECIAL RECORDING CAMERA REQUIRED

The picture contrast is sufficient for making photographic records with simple cameras, since the exposure time can be prolonged as required. Built-in glare-free illumination of the screen enhances the contrast of the dark-blue picture to the bright background and thus makes possible observations in dark rooms.

TYPICAL SPECIFICATIONS

Frequency range: 0 to 10 kc
Y sensitivity: 3 V/cm
X sensitivity: 1 V/cm
Time base: 0.01 to 10 secs.
Storage time: Several days
Erasing time: Approximately 20 secs.
Screen area: 3½" x 5"
Input: 100 kΩ, unbalanced

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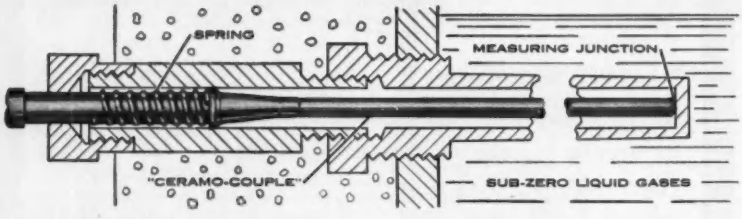
Sub-Zero *Ceramo-Couple* Solves Condensation Problems



"Ceramo" versatility has also solved a key problem of *sub-zero temperature measurement*—condensation. Caused by wide temperature differences between ambient temperatures and the thermocouple measuring point, condensation can penetrate thermocouple insulation and short out conductors.

Overall Metal Sheathing of "Ceramo" thermocouple wire completely encloses conductors and ceramic insulation—shutting out moisture effectively. Sheathing itself is stainless steel or other corrosion-resistant material.

Spring-Loaded Construction of T-E's sub-zero probe holds contact point firmly against thermowell end—counteracting effects of expansion and contraction from temperature changes.

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Write For Bulletin 52-B

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ABSTRACTS

the preceding filter studies are applicable to many aircraft interception systems.

The problem of storing air-to-air missiles on parent airplanes has led to the consideration of wingless or very low aspect ratio missiles. These missiles rely on body-lift capabilities for maneuvering which require large pitch and yaw angles. The effects of these large angles on the performance of a navigation system was investigated analytically. It was shown that a problem requiring careful attention is space stabilization of the radar antenna against body motions.

Guidance and control requirements for antiballistic missiles have been investigated, considering both aerodynamic and reaction controls. Two types of interception were considered; one in which the relative-approach speed is small compared with the target speed, and the other where the relative-approach speeds are extremely large as would be associated with head-on interception. As part of this study, roll stabilization of hypersonic vehicles was investigated. Considered were the effects of large fuel expenditures and large dynamic pressure variations.

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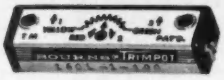

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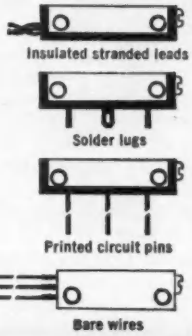

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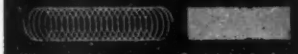

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NEW BOOKS

Transistor Compendium

MODERN TRANSISTOR CIRCUITS, *By John M. Carroll, Managing Editor, Electronics. 268 pp. Published by McGraw-Hill Book Co., New York.* $8.50.

This book offers a comprehensive collection of modern transistor circuits, classified and arranged for easy reference. Almost 200 circuits are included, with complete design information and electronic component values for each. Circuits are arranged both by generic types such as amplifiers, oscillators, power supplies, and pulse circuits, as well as by specialized applications such as broadcast equipment and home entertainment; audio and r-f communications circuits; missile, aircraft, and satellite telemetering equipment; test instruments; and industrial, scientific, and medical devices. Chapter divisions have been selected on a functional design basis. For example, the book considers industrial electronics under three subheadings: Industrial Measuring Instruments, Industrial Control Equipment, and Industrial Detection Systems. Similar treatment is accorded circuits for communications, broadcasting, computing, and scientific and medical devices.

Emphasis is given to new circuits combining transistors and electron tubes, and transistors and magnetic amplifiers. There are over 200 schematic diagrams, in addition to important block diagrams, performance curves and waveforms, and photographs illustrating construction of equipment. The book provides a compact and rapid summary of work done in more than a dozen fields of transistor circuits design, based on articles in *Electronics* magazine.

Guide to Programming

PROGRAMMING FOR DIGITAL COMPUTERS. *By Joachim Jeenel, Computing Laboratory, Columbia University. 517 pp. Published by McGraw-Hill Book Co., New York.* $12.

Designed for readers with no previous programming experience, this work provides a methodical approach to the preparation of problems for stored-program calculators. The approach is based on the representation of a program as a logical structure of standardized building blocks. This structure serves two primary purposes: (1) to provide a conceptual framework

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Designer's Fact File from DENISON

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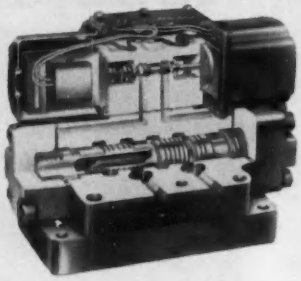

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Write For Details In Bulletin 240-B.

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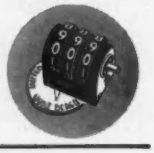

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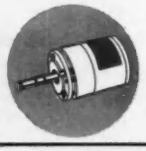

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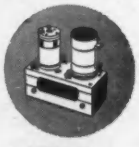

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within which the programmer can create a program more rapidly and efficiently, and (2) to permit programs for different purposes and machines to be presented in a uniform manner.

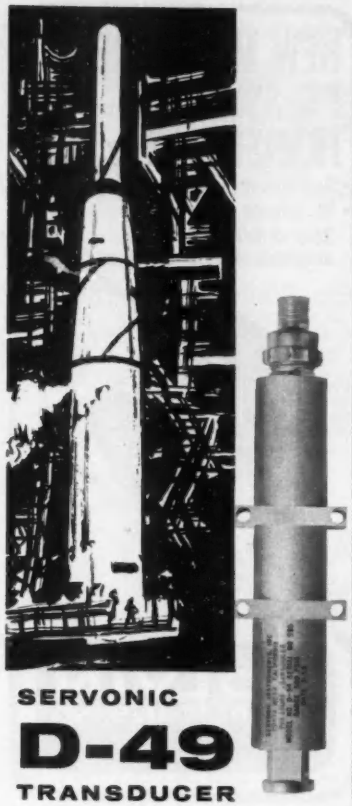
The principles and procedures presented apply to scientific and technical problems, as well as to commercial data processing. They are not restricted to specific machines, but apply to stored-program calculators in general. The book covers recent developments and specific topics such as indirect addressing, randomized addresses, random-access storage, in-line processing, concurrent operations, and non-machine languages.

The standardized methods included in this book should prove advantageous in many respects. They should promote more efficient exploitation of data-processing equipment and reduce the time and effort required of personnel for programming and related activities such as testing programs, adapting existing programs to new applications, and operating the equipment. A methodical approach to programming should generally facilitate communication between man and machine as well as communication among humans about topics relating to the use of data-processing equipment. The text has been made as self-contained as practical in order to serve as an introduction for those readers who have had no programming experience.

Proceedings Available

PROCEEDINGS OF THE NATIONAL ELECTRONICS CONFERENCE, Vol. 14, 1958. 1080 pages. *Published by National Electronics Conference, 228 N. LaSalle St., Chicago 1, Ill.* 7.50.

Proceedings of the 1958 National Electronics Conference contains transcripts of the papers and discussions presented at the three-day international meeting held in Chicago last October. Papers describe latest developments in a wide range of areas including transistors, servomechanisms, antennas, solid state components, audio circuits, navigation, network theory, microwaves, instrumentation, noise, engineering writing and speech, computers, magnetic amplifiers, industrial electronics, and engineering management. The book also features transcripts of sessions on the International Geophysical Year and speeches by General John Medaris, Deputy Defense Secretary Donald B. Quarles, and Dr. Simon Ramo.



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MEETINGS

JULY

Case Institute of Technology, 10-Day Short Course on Numerical Feedback Control, conducted by Dr. Harry W. Mergler, Case Institute of Technology, Cleveland
July 6-17

Sixth Annual Symposium on Computers and Data Processing, sponsored by Denver Research Institute of University of Denver, Stanley Hotel, Estes Park, Colo.
July 30-31

AUGUST

University of North Carolina Extension Division, Course in Frontier Research on Digital Computers, University of North Carolina, Chapel Hill
Aug. 17-28

Western Electronic Show & Convention (WESCON), sponsored by IRE and AIEE, Cow Palace, San Francisco
Aug. 18-21

University of West Virginia School of Mines, 19th Annual Appalachian Gas Measurement Short Course, University of West Virginia, Morgantown
Aug. 24-26

Gordon Research Conference on Instrumentation, Colby Junior College, New London, N. H.
Aug. 24-28

SEPTEMBER

American Automatic Control Council, General Assembly of IFAC, Edgewater Beach Hotel, Chicago
Sept. 14-18

Instrument Society of America, 14th Annual Instrument Automation Conference & Exhibit, International Amphitheater, Chicago
Sept. 21-25

Fourth Annual Special Technical Conference on Nonlinear Magnetics and Magnetic Amplifiers, sponsored by IRE and AIEE, Shoreham Hotel, Washington, D. C.
Sept. 23-25

Institute of Radio Engineers, 1959 National Symposium on Telemetering, Civic Auditorium, San Francisco
Sept. 28-30

American Society of Mechanical Engineers, National Power Conference, Muehlebach Hotel, Kansas City
Sept. 28-Oct. 1

OCTOBER

National Electronics Conference, sponsored by AIEE, IRE, Illinois Tech, Northwestern University, and University of Illinois, Sherman Hotel, Chicago
Oct. 12-14

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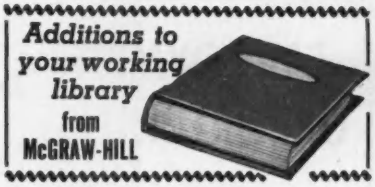

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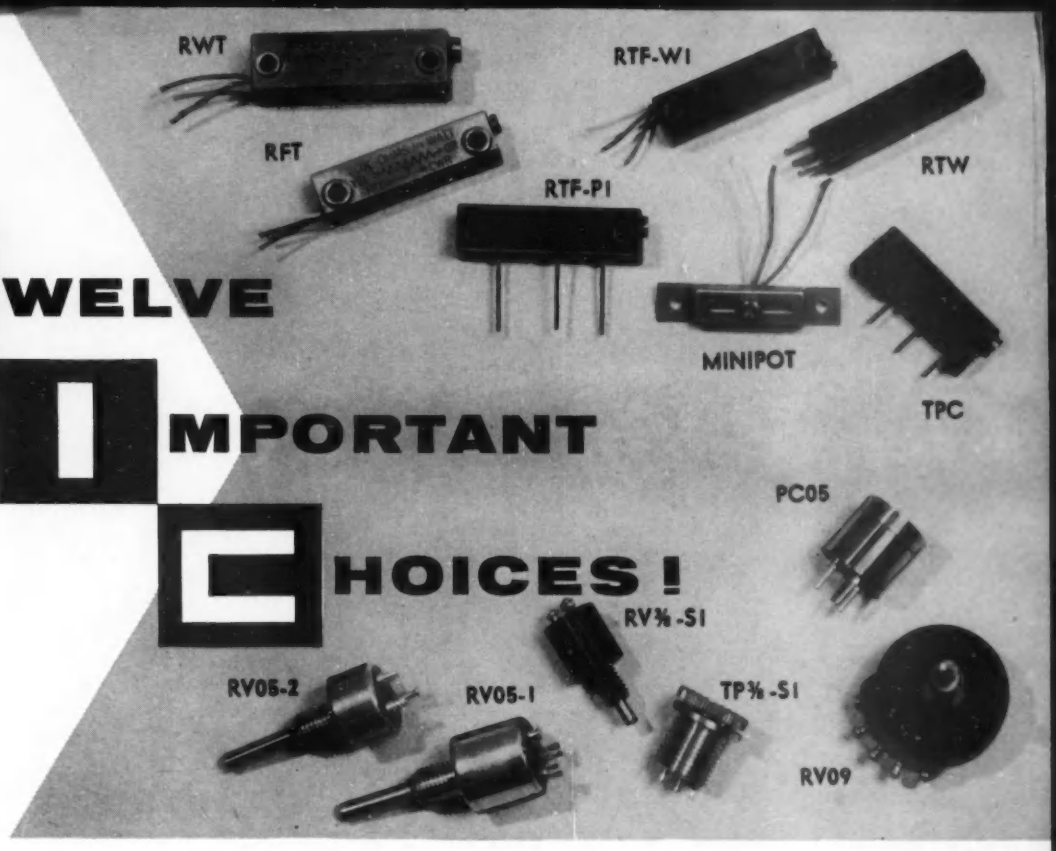

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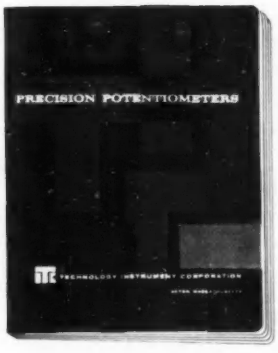

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How proud I was with my shiny badge, bucket and bright yellow helmet. Each morning I sat by as my crew dropped a flowmeter out of the line. Then, a quick dip in detergent, and into the meter I jumped, forebrushes swinging. They were happy days, in spite of the inevitable tight spots. Many's the venturi I've squeezed through, and I carry the scars of any number of disgruntled orifices.

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Meter cleaners of the world . . . UNITE! Every day Fischer & Porter turns out more of these new meters that can measure tougher liquids, with lower and lower conductivities. They're already down to one micromho per centimeter . . . less than distilled water. Your job may be next. If you don't believe me, ask for your copy of Catalog 10D1416. Write Fischer & Porter Company, 779 County Line Road, Hatboro, Pa. In Canada, write Fischer & Porter (Canada) Ltd., 2700 Jane Street, Toronto, Ontario.

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